

STROBE FLASHER FOR NIGHT CYCLING SAFETY

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WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

OCTOBER 1976/\$1

FOR TAPE RECORDISTS

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What's New in Tape Recorders

FOR HOBBYIST WORKBENCHES

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Experimenters

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Editorial

SOLAR ENERGY

People continually ask me, "What do you think the next hot product will be?" Of late, I've answered, "solar energy devices," mischievously. When pressed, however, I'll readily admit that it won't really be the *next* exciting product for the public, but one day solar energy will surely have a significant impact on our lives.

Today, there are a few solar-powered homes, most of them experimental and, without mass-produced solar panels, certainly costly. But Edmund Scientific Company's catalog devotes three pages to energy-from-the-sun devices, so there's obviously a coterie of hobbyists already experimenting in this field. There's also a host of recent books published on solar energy (though nothing approaching the plethora of books on CB radio) as well as journals, newsletters and industry directories.

In truth, energy from the sun to heat homes and feed electric appliances is not destined to provide us with a very substantial part of our power needs in the near future. Estimates of solar power expected to be supplied in the U.S. are not at all awesome at this time. For example, projections by the Energy Research and Development Administration (ERDA) indicate only 0.07% of our energy consumption to be from solar means by 1985, 5% by the year 2000 and 15% by 2020. But though percentages are not great, it still adds up to a lot of power (almost 1½ electrical gigawatts in 1985).

Solar thermal system research is moving along, however, with about 31-million dollars budgeted for 1977 by ERDA (compared to almost 1.1-billion dollars for breeder nuclear reactor and fusion systems). But the greatest potential for making use of the sun's energy for electric power rests with satellite solar stations orbiting the earth. Materials launched from the earth can then be assembled at zero gravity to simplify the operation. More importantly, the sun is always shining beyond our atmosphere and it's a virtually unlimited energy source. The solar energy would be transmitted to earth by beaming microwave energy to a receiving station. (Klystron amplifying tubes won't be needed because space is a vacuum.)

Although the benefits of solar energy for obtaining massive amounts of electric power will not become apparent to many of us in our lifetime, low-power needs are today being met by this source. There are solar-powered wrist-watches in use and solar food-cooking apparatus. Automatic electric generators that get all their power from the sun are being produced for army units in Israel. So on a small scale, solar energy is being used right now; and it shows promise of having much wider applications even with present technology.

With silicon solar cells and panels widely available to experimenters at modest cost, we expect more and more POPULAR ELECTRONICS readers to develop solar power supplies for a variety of needs. We will publish plans for building an inexpensive, reasonably accurate solar meter in an upcoming issue. It will enable one to make quantitative measurements of solar energy.

Art Salsberg

From Dynascan Corporation

Good things
DO come in small packages...



ACTUAL-SIZE PHOTO (5.24" x 7.25" x 11.2")

Model 1403A \$209

B&K-PRECISION ANNOUNCES A NEW 5MHz 3" SCOPE

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Perhaps the most striking feature of the 1403A is its ultra-compact size, (HWD) 5.24 x 7.44 x 11.2".

This feature, combined with a sturdy integral handle, makes the 1403A ideal for field service applications. When bench or storage space is at a premium, you'll come to appreciate the convenient size even more.

We think the 1403A is the most cost-effective small scope available. Compare the specs, features, size and price, and we're sure that you'll agree. Available options include the LC-14 carrying case and PR-21 isolation/ direct probe.

For immediate delivery, contact your B&K-PRECISION distributor.

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Letters

BUILDING THE COSMAC "ELF"

Congratulations on "Build the Cosmac 'Elf'" (August, p 33). It is refreshing to read about a project that involves an MPU other than the 8080 or 6800.—W. J. Habernern, Cocoa Beach, FL.

I very much enjoyed "Build the Cosmac 'Elf'" in the August issue. The price and complexity were just at my level.—D. Morris, Midland, MI.

I really appreciated the Cosmac "Elf" article. I intend to build it as soon as I have found suppliers for the parts. In my search for the parts, I have encountered some problems:

(1) The article says that the CDP 1802 microprocessor sells for less than \$30. The only supplier that I could find for the chip sells it for \$40.

(2) The memories called for are 2101 (256 × 4). Every 2101 I can find is 256 × 1.

(3) I have been unable to find the 5082-7340 hex displays anywhere. I realize that others could be substituted but I would like to use the one suggested.—David Borgelt, Kingdom City, MO.

In answer to Dave's questions, we have the following information: (1) The MPU you want is CDP1802CD. (The last CD means 4-6-volt operation in a ceramic package.) It sells for \$29.50. RCA tells us that the MPU has been in short supply due to the heavy demand, but it should be available again soon. A list of RCA-appointed distributors around the country and CDP1802CD data sheets are available free of charge from: RCA Solid State Division, Box 3200, Somerville, NJ 08876.

(2) Despite what some advertisements may say, the 2101 is 256 × 4.

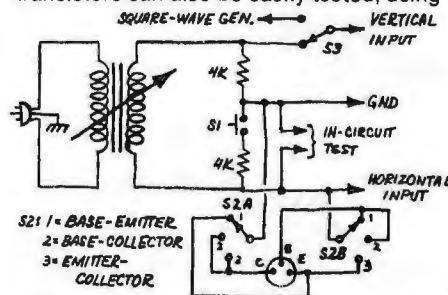
(3) The 5082-7340 displays are available from most distributors who carry Hewlett-Packard products.

A BETTER CURVE TRACER

I would like to make a few comments about the circuit in "Curve Tracer Checks Semiconductor Quality" (March 1976). First, this circuit will not check zener diodes rated at voltages greater than the transformer's 12.6-volt secondary potential. Any zener diode rated at greater than this voltage will produce a trace like an ordinary pn junction. Secondly, the largest capacitance that can be tested is 1 μ F. Values greater than this will produce a

"shorted" trace, while values less than 0.033 μ F will produce an "open" trace. The limitation here is the 60-Hz line frequency; a possible answer to this would be to use a signal generator in lieu of the filament transformer. Finally, with the base open, a true picture of the device under test cannot be represented, since the base-emitter junction is very important to the operation of the device. The Beta test circuit can be enhanced by use of a signal generator to permit the frequency to be changed and thus give a better picture of gain.

Below is a circuit I have used quite often for testing semiconductors, rheostats, capacitors, and coils. The variable transformer allows for a wider range of test voltages to solve the zener test problem. Power transistors can also be easily tested, using



a calibrated dial to list selected test voltages. Switch S3 can be used to switch in an external square wave (scope calibrator or signal generator) for ringing coils. Switch S2 provides fumble-free out-of-circuit testing.—D.D. Dempsey, Fort Gordon, GA.

VIDEO GAME READER NOTES

I've seen two table tennis (April 1976) games that have the same flaw: The vertical interval from the vertical sync generator (Fig. 2) is too long. I've seen it as long as 28 lines when it's supposed to be only three horizontal lines. Also, with the components specified, a 60-Hz vertical rate can't be obtained. I've discovered that by increasing the value of C3 to 0.15 or 0.12 μ F and decreasing the value of R10 to 1500 ohms, the problem will clear up, and tearing at the top of the displayed picture will cease.—Cary Sagady, Lindenwold, NJ

I couldn't resist building the "Space War" game (April 1976), but when I got it up and running, the space ships remained at the top of the screen and I had little control over their positioning. I discovered that the trailing edge of the 555's output occurred about 1 ms after the vertical sync pulse. By changing the values of C14 and C15 to 4.7 μ F and inserting a 470-ohm resistor in series with each position-control potentiometer's wiper, I solved the problem.—Charles F. Brillowsky, Southgate, MI

ULTRA-UNIQUE DEVICES

It appears that POPULAR ELECTRONICS is continuing with construction projects that contain ultra-unique components. After

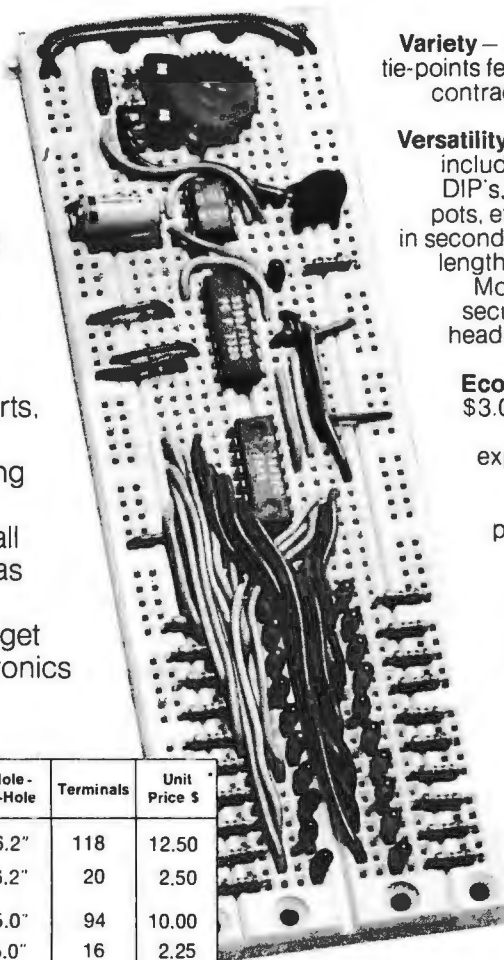
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EVERY PROJECT IN THIS BOOK IS ANOTHER REASON TO OWN CSC'S QT SOCKETS AND BUS STRIPS.

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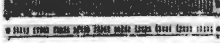








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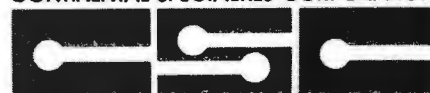
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	QT-47B	5.3"	5.0"	16	2.25
	QT-35S	4.1"	3.8"	70	8.50
	QT-35B	4.1"	3.8"	12	2.00
	QT-18S	2.4"	2.1"	36	4.75
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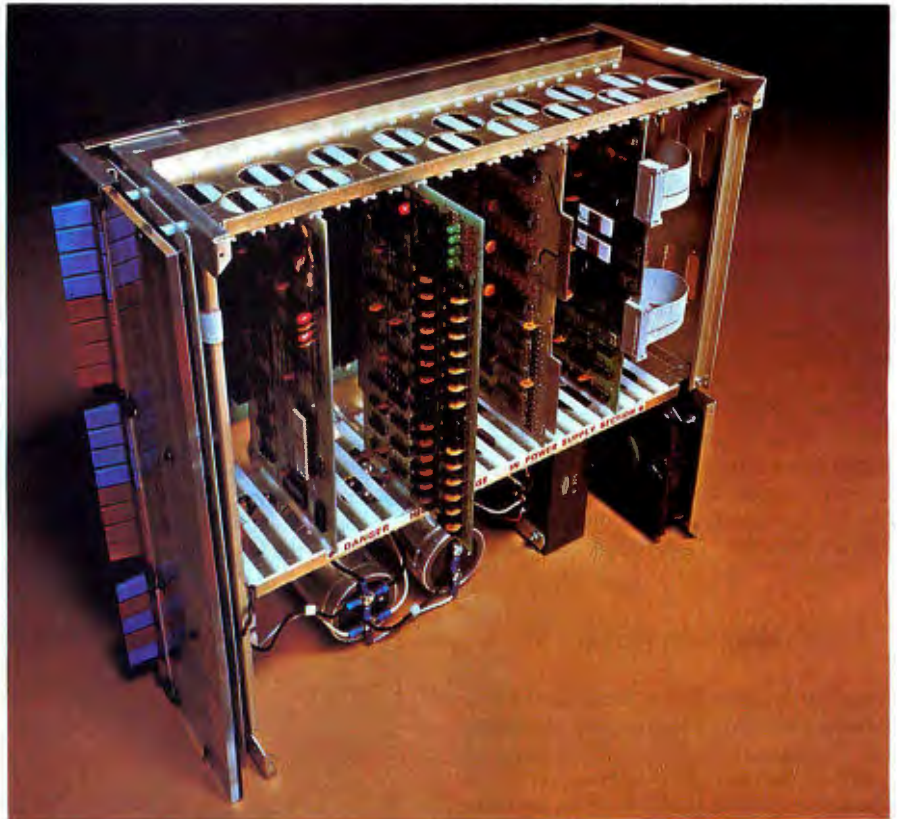
think IMSAI 8080.

Sure there are other commercial, high-quality computers that can perform like the 8080. But their prices are 5 times as high. There is a rugged, reliable, industrial computer, with high commercial-type performance. The IMSAI 8080. Fully assembled, it's \$931. Unassembled, it's \$599. And ours is available now.

In our case, you can tell a computer by its cabinet. The IMSAI 8080 is made for commercial users. And it looks it. Inside and out! The cabinet is attractive, heavy-gauge aluminum. The heavy-duty lucite front panel has an extra 8 program controlled LED's. It plugs directly into the Mother Board without a wire harness. And rugged commercial grade paddle switches that are backed up by reliable debouncing circuits. But higher aesthetics on the outside is only the beginning. The guts of the IMSAI 8080 is where its true beauty lies.

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The IMSAI 8080 power



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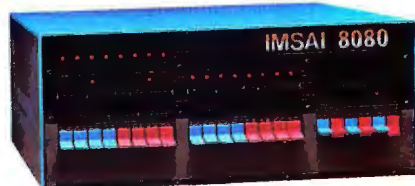
You can expand to a powerful system with 64K of memory, plus a floppy disk controller, with its own on-board 8080—and a DOS. A floppy disk drive, an audio tape cassette input device, a printer, plus a video terminal and a teleprinter. These peripherals will function with an 8-level priority interrupt system. IMSAI BASIC software is available in 4K, that you can get in PROM. And a new \$139 4K RAM board with software

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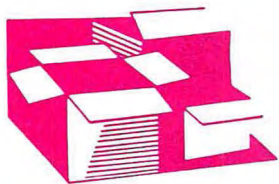
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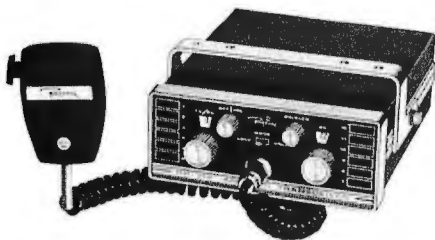
Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

SWL FREQUENCY CALIBRATOR

Gilfer Associates' Model C-10 calibrator provides selectable marker signals every 10, 25, 50, 100, and 1000 kHz across the long- and short-wave regions of the radio spectrum. A front-panel gating switch enables identification of markers even on a crowded band. The calibrator uses 3 CMOS IC's and a transistor amplifier, and draws low current from an internal 9-volt battery. Enclosed in a Ten-Tec cabinet. \$54.00. Address: Gilfer Associates, 52 Park Avenue, Box 239, Park Ridge, NJ 07656.

2-METER FM TRANSCEIVER

Regency Electronics has introduced a new 2-meter FM amateur transceiver, the Model HR-312. Selection of 12 crystal-controlled simplex channels or 144 transmit/receive frequency combinations is made by lock-



ing or unlocking the transceiver's mode switch. Adjacent channel selectivity is rated at 75 dB, intermodulation rejection at 65 dB, and receiver sensitivity at 0.15 μ V at 12 dB SINAD. Transmitter power is rated at 35 watts. Comes with a mounting bracket and a PTT microphone. \$269.00.

CIRCLE NO. 85 ON FREE INFORMATION CARD

SHURE STEREO/FOUR CHANNEL CARTRIDGE

The new Shure Model M24H Dynetic cartridge features low effective stylus mass (0.39 mg), and a hyperbolic diamond stylus tip, making it suitable for use with stereo, matrix, and discrete quadraphonic discs. Its frequency range is said to be 20 to



50,000 Hz, its output 3.0 mV per channel at 1000 Hz with a 5 cm/sec peak recorded velocity, and channel balance within 2 dB. Channel separation is rated at a minimum of 22 dB at 1000 Hz. Typical trackability at 1 1/4 grams in a Shure/SME tone arm is 20 cm/sec at 400 Hz and 25 cm/sec at 30,000 Hz, with a peak of 50 cm/sec at 10,000 Hz. Tracking force ranges from 1 gram minimum to 1 1/2 grams maximum, with an optimum figure of 1 1/4 grams. Net weight is 6 grams. \$74.95.

CIRCLE NO. 86 ON FREE INFORMATION CARD

CB BASE MIKE WITH PREAMP

The new Expander 500 from Turner is a base-station microphone with a built in preamp. Slide-type volume and tone controls, together with a meter, allow the user to adjust the microphone output for



maximum intelligibility. The meter also functions as a battery-condition indicator when used with a press-to-test button. The mike head has adjustable tilt and a press-to-talk bar with a slide lock. Comes with a six-conductor (one shield) cable. \$65.00.

CIRCLE NO. 87 ON FREE INFORMATION CARD

WESTON PORTABLE LCD DMM

Weston Instruments' new Model 6000 is a portable digital multimeter with autoranging for five measurement functions: ac voltage, ac current, dc voltage, dc current, and resistance. Twenty-six ranges cover voltage measurement from 200 mV to 1000 V, current from 2 mA to 10 amperes, and resistance from 200 ohms to 20 megohms. A HOLD input jack provides memory reten-

tion capability for remote measurements. Automatic zero and automatic polarity are built-in. Accuracy for the Model 6000 is said to be 0.35%. The 3 1/2-digit liquid crystal display has 0.5-inch high characters, and blinks on over-range. Uses two 9-volt transistor batteries. Measures 7" x 5.75" x 2.25" (17.8 x 14.6 x 5.7 cm); weighs less than 2 lb. \$195.00.

CIRCLE NO. 88 ON FREE INFORMATION CARD

CORDLESS SOLDERING IRON

Wahl Clipper Corp.'s new Model Iso-Tip 60 is a rechargeable soldering iron that is said to be able to heat up to 125 joints on a single charge. It can be recharged from "dead" to "full" in one hour, at which point



a LED indicator lights. The iron can be kept in its recharging stand, where it will be trickle-charged if the battery is not discharged or fast-charged if it is low. The standard cordless soldering kit, Model 7800, includes the Iso-Tip 60 soldering iron, recharging stand, a fine tip, a chisel tip, and an instruction booklet. The iron will also accommodate any of Wahl's 16 snap-in soldering tips.

CIRCLE NO. 89 ON FREE INFORMATION CARD

BIC MONITOR SERIES LOUDSPEAKER

The new Formula 7 speaker system by BIC Venturi has a ported bass reflex design with a 12-inch woofer, a "T-slot" horn assembly with a dynamic compression driver for the midrange and lower treble, and a piezo-electric driver for the upper treble range. It also features an amplifier clipping indicator which glows when the amplifier is being over-driven. The woofer and midrange/treble transducer are protected by overload indicator lights and circuit breakers. Also included are a midrange/treble level control, a dynamic tonal balance circuitry, and a series of indicators which measure the output sound level over a range of 75 to 117 dB. Claimed frequency range is 20 Hz to beyond 30,000 Hz; power handling is rated at 125 W rms/channel; dispersion is 180° horizontal, 120° vertical. Nominal impedance is 6 ohms. Cabinet

POPULAR ELECTRONICS

The small wonder



of the micro-world

Measuring just 11" wide x 11" deep x 5" high, and weighing a mere 7 pounds, the Altair™ 680b is a complete, general-purpose computer.

The secret to this revolutionary, small computer is its CPU board. This double-sided board fits along the bottom of the Altair case and plugs directly into the front panel board. It contains the new 6800 microprocessor, 1,024 bytes of RAM memory, a 256 byte PROM monitor, provisions for 768 bytes of additional PROM or ROM, and a single Interface port with a Motorola ACIA serial interface adapter which can be configured either RS-232 or TTY. A five level Baudot interface option is also available.

The Altair 680b can be programmed from front panel switches, or it can be interfaced to a video display terminal, or teletypewriter. Three additional circuit boards can be plugged inside the Altair 680b for further memory and interface expansion. The first of these boards is a 16K static RAM memory board.

Software already developed includes Altair 680 BASIC with all the features of the 8K BASIC previously developed for the Altair 8800. These include Boolean operators, the ability to read or write a byte from any I/O port or memory location, multiple statements per line, and the ability to interrupt program execution and then continue after the examination of variable values. This software takes only 6.8K bytes of memory space and a copy is included free with the purchase of the Altair 680 16K memory board.

Other software includes a resident two pass assembler. The Altair 680b is also compatible with Motorola 6800 software.

The Altair 680b is ideal for hobbyists who want a powerful computer system at an economic price. Altair 680b owners qualify

for membership in the Altair Users Group, and like other Altair owners, they receive a complimentary subscription to **Computer Notes** and complete factory support.

PRICES:

Altair 680b kit with complete, easy-to-understand assembly manual, operator's manual, and programming manual	\$466
Assembled Altair 680b	\$625
Altair 680b Turnkey model kit	\$395
Expander Card 680MB (required to expand 680)	\$ 24
Altair 680BSM 16K static RAM board kit with 680 BASIC	\$685
Altair 680 BASIC when purchased separately	\$200
Baudot option	\$ 42

MAIL THIS COUPON TODAY

- ☐ Enclosed is a check for \$ _____
- ☐ BankAmericard # _____ or Master Charge # _____
- ☐ Altair 680b ☐ Kit ☐ Assembled ☐ Other (specify) _____
- enclose \$8 for postage and handling
- ☐ Please send free information package.

NAME _____

ADDRESS _____

CITY _____ STATE & ZIP _____

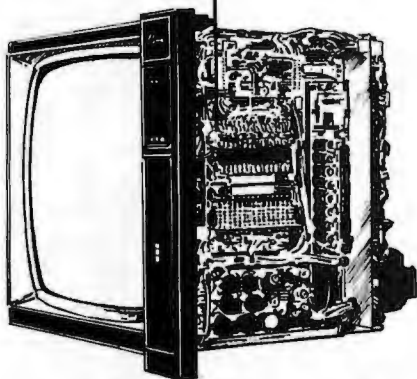


2450 Alamo SE/Albuquerque, NM 87106, 505-243-7821

NOTE: Altair is a trademark of MITS, Inc.

Price, specifications subject to change. Please allow up to 60 days for delivery.

Three different schools give you this 25" DIAGONAL hobby-kit Color TV...



No other home training school gives you both an exclusive solid state color TV and an SQ® Quadraphonic Receiver complete with four speakers . . . all in one course. You get both for hundreds of dollars less than the combined tuition cost of TV and Audio courses at another school. And only NRI's Master Course in Color TV/Audio servicing lets you train on equipment specifically designed for training with exclusive "power-on" features.

NRI doesn't give you hobby kits or commercial sub-assemblies. We invested the time and money to design equipment with learning in mind.

It's the only way you can (1) get the feel of typical commercial circuitry, (2) learn bench techniques while building complete units from the "ground" up, (3) perform over 35 "in-set" experiments during construction, and (4) end up with a 25" diagonal solid-state color TV with console cabinet and a 4-channel quadraphonic Audio Center.

NRI passes the savings on to you

NRI can save you money because our engineering eliminates the cost of buying from an outside source. We pay no salesman's commission. Students are enrolled by mail only. The savings are passed on to you in the form of low tuition fees, extras like the TV's console cabinet and the four speaker Quadraphonic System; a 5" triggered sweep

Only NRI gives you this 25" DIAGONAL designed-for-learning Color TV...

oscilloscope, CMOS digital frequency counter, and an integrated circuit color TV pattern generator. Where NRI supplies a professional color



pattern generator, most other schools use a TV set with a built in alignment generator of no use for servicing other sets. Only NRI designs, engineers, and supplies training kits specifically for learning and professional use. You can pay hundreds of dollars more for a similar course and not get a nickel's worth more in training and equipment.

...plus complete Quadraphonic Audio Center!

More know-how per dollar

That's what it all boils down to, the quality of training you get for the money you spend. In our 62-year history, more than a million students have come to NRI and we're fully approved for career study under the G.I. Bill. We must be teaching something right. Some of those "right" things are bite-size lessons to ease understanding and speed learning . . . personal consultation, and prompt grading of all tests . . . a full-time staff of engineer/instructors to help if you need it . . . plenty of kits and experiments to give you hands-on training . . . and fully professional

programs oriented to full or part-time career needs.

Widest Choice of Courses with Communications, CB, Digital Computer, and other careers.



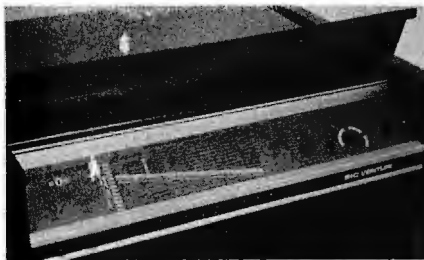
NRI offers not one, but five excellent TV/Audio servicing courses so you can tailor your training to your budget.

Or you can study other opportunity fields like Digital Computer Electronics, Citizens Band Radio, Communications, Aircraft or Marine Electronics, Mobile Radio, and more. Send for our free catalog and see for yourself that no one gives you more training and equipment for your dollar. There's no obligation, and no salesman will call.

If card is missing, write to:



NRI SCHOOLS
McGraw-Hill Continuing
Education Center
3939 Wisconsin Avenue,
Washington, D.C. 20016



finish is walnut veneer, and front grille is dark brown. Measures 41¼" H x 16" W x 13¾" D (104.8 x 40.6 x 34.9 cm), weighs 88 lb (40 kg). \$445.

CIRCLE NO. 91 ON FREE INFORMATION CARD

BREAKER CB BURGLAR ALARM

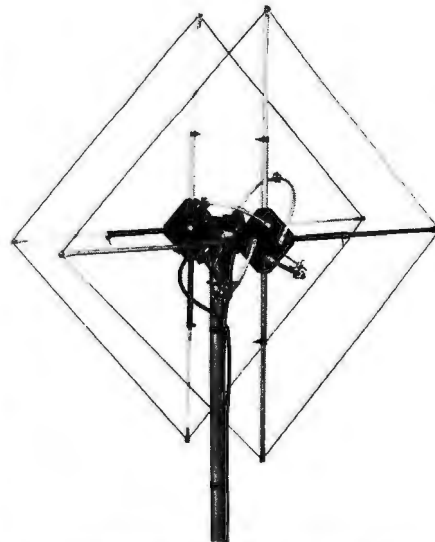
The Model 13-188 CB burglar alarm from Breaker Corp actuates the horn of the ve-

hicle in which it is installed if the ground connection to either the antenna or the transceiver is broken. Once actuated, the horn will continue to sound — even if the ground connection is quickly restored — until the alarm is reset. Designed for use in vehicles with 12-volt negative- or positive-ground electrical systems, the alarm is said to be easy to install. \$21.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

CB QUAD BASE ANTENNA

The Avanti PDL II is a cubical quad base station antenna. It has two elements and a gamma match which dc grounds the antenna. Front-to-back rejection is rated at 32 dB. VSWR is said to be 1.2:1. Boom length is 4'10" (1.5 m). Requires a light-to-medium duty rotor. The quad uses aluminum tubing

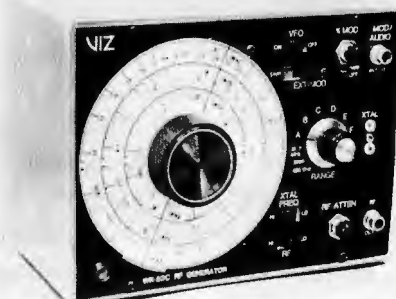


spreaders, cast aluminum hubs, stainless steel clamps and cadmium-plated hardware. \$108.95.

CIRCLE NO. 93 ON FREE INFORMATION CARD

RF SIGNAL GENERATOR

VIZ Test Instruments Group has introduced its Model WR-50C solid-state signal generator, a successor to the RCA WR-50B. It covers fundamental frequencies from 85 kHz to 40 MHz in six ranges, and harmonic outputs for higher frequencies. The range-selection switch also has two



positions for 455 kHz and 10.7 MHz sweep outputs for AM and FM radio i-f alignment. R-f output is rated at 75 mV minimum. The generator has a built-in modulator and a crystal controlled oscillator circuit with front-panel crystal socket for markers or calibration. A two-step 10:1 attenuator switch is included, as are a vernier attenuation control for sweep output, and a two-position 7:1 attenuator switch for crystal oscillator output. Measures 7¾" x 5½" x 4½" (19.7 x 14.9 x 10.5 cm). \$117.00.

CIRCLE NO. 94 ON FREE INFORMATION CARD

TECHNICS INTEGRATED STEREO AMPLIFIER

The new Model SU-8600 from Technics by Panasonic has a rated power output of 73 watts per channel minimum (rms) at 8 ohms from 20 to 20,000 Hz with no more than 0.08% total harmonic distortion. It is a complementary direct-coupled OCL power

NOW FROM TEXAS INSTRUMENTS . . . three machines in one.

programmable
slide-rule calculator
SR-52



- 10 user defined keys
- 224 program storage locations
- 23 preprogrammed key functions
- 8 preprogrammed condition statements
- 20 independent addressable memory registers
- Permanent program storage on magnetic cards

It took TEXAS INSTRUMENTS to invent the SR-52 calculator. It took C & S MARKETING ASSOCIATES to offer it at a price you can afford, now only \$249.95. With such versatility and such an affordable price, you can not afford to be without the problem solving power of card programmability. Now solve problems in seconds that would take hours with an ordinary calculator or sliderule if they could be done at all.

For more information or the answer to any question you may have about the SR-52 calculator, call toll free (800-251-6771)*. Tenn. residents call (800-262-6706). Other TEXAS INSTRUMENT models available from \$49.95.

Each TEXAS INSTRUMENT calculator comes with a 1-year warranty. Should your unit prove defective within 60 days, just return it for a new unit! Finally should you be dissatisfied with your calculator return it within 15 days for a prompt refund. * COD orders please add \$5.00 shipping and handling.

C & S MARKETING ASSOC.
P.O. BOX 165 ALGOOD, TENN. 38501

QTY. _____ PRICE 249.95 ea.

☐ CHECK ☐ M.O. ☐ C.O.D.

NAME _____

ADDRESS _____

CITY, ST., ZIP _____

CIRCLE NO. 16 ON FREE INFORMATION CARD



When you've got a Pace CB radio,



you've got the world by the ears.

There are millions out there with their ears on waiting to talk to you Pace to Pace.

And with a Pace CB two-way radio you've got every bit of power the law allows. Power to cut through interference and "bleeders" from other channels.

What's more, it's assembled with computerized circuitry and it's 100% solid state, so it's as trouble-free as a CB can be.

It all adds up to your voice getting out there clearer and with less distortion, and the

other guy's voice coming back just as clear.

To learn more, drop into a Pace place near you. The dealer will tell you just how economical and easy-to-install a Pace is. He'll help you choose the one that's just right for you, too.

Ask him for the best-selling CB in the world. He'll know which one you're talking about.



PACE CB 144

PACE CB

PACE TWO-WAY RADIO PRODUCTS.
BY PATHCOM, INC., HARBOR CITY, CA 90710

Saving the best for last.

The chances are good that when you first bought a stereo system, it was a "package" that included a receiver, 2 speakers, and a record player with cartridge. But how much time was spent selecting the cartridge? Most probably it was just a minor element of the package. Even if it had a famous name, it probably was not a truly first-rank model.

Yet the cartridge is more important than that. It can limit the ability of the entire hi-fi chain to properly reproduce your records. It can affect how many times you will enjoy your favorite records without noise and distortion. And it can determine whether you can play and enjoy the new four-channel CD-4 records.

Consider the advantages of adding an Audio-Technica AT15Sa to your present system. You start with response from 5 to 45,000 Hz. Ruler flat in the audio range for stereo, with extended response that assures excellent CD-4 playback if desired. Tracking is superb at all frequencies and distortion is extremely low. The sound is balanced, transparent, effortless. Stereo separation is outstanding, even at 10kHz and higher where others fall short. Our Dual Magnet design* assures it.

And the AT15Sa has a genuine nude-mounted Shibata stylus. Which adds a host of advantages. Like longer record life. Better performance from many older, worn records. Exact tracing of high frequencies, especially at crowded inner grooves. And tracking capability—at a reasonable 1-2 grams—that outperforms and outlasts elliptical styli trying to track at less than a gram.

We're so certain that an AT15Sa will improve your present system that we'd like to challenge you. Take several of your favorite records to an Audio-Technica dealer. Have him compare the sound of your present cartridge (or any other) with the AT15Sa. Listen. We think you'll be impressed. And convinced.

*T.M. Audio-Technica Dual Magnet cartridges protected by U.S. Patent Nos. 3,720,796 and 3,761,647.

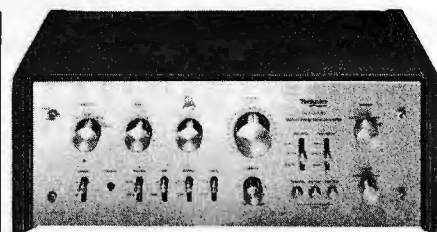
**The AT15Sa.
Very possibly the
last phono
cartridge
you'll ever
need.**



audio-technica®

INNOVATION □ PRECISION □ INTEGRITY

AUDIO-TECHNICA U.S., INC., Dept. 106P, 33 Shiloh Ave., Fairlawn, Ohio 44131
Available in Canada from Superior Electronics, Inc.



amplifier with differential input stage and an emitter follower for impedance matching. It also has a 2-stage phono equalizer. A current-mirror differential amplifier is employed in a 3-stage direct-coupled tone-control circuit. Other features include a turnover frequency selector, a tone-defeat switch, a 26-step attenuator-type level control with loudness switch, -12-dB/octave low and high filters, a -20-dB audio muting switch, two speaker system outputs, two tape monitor loops, a head-phone jack, and inputs for two phono-graphs, a tuner, and an auxiliary signal source. \$329.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

CB CHANNEL BILLBOARD

Controls/Inc. announces its new CB Channel Billboard Advertiser, which allows a mobile operator to display which channel he is monitoring. It is composed of two units. One is a display box with 2-inch (5-cm) seven-segment numerals to indi-



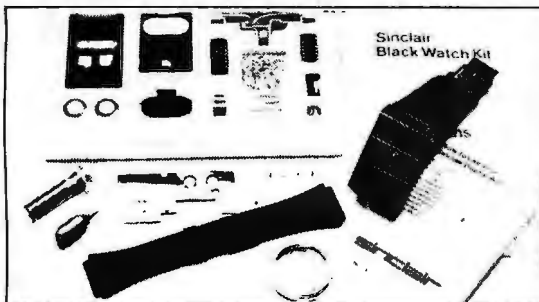
cate the monitored channel. It can be mounted on the rear deck of an automobile or in any other visible location. The second unit is a control box with a 24-position rotary switch (1 through 23 and OFF). The two are interconnected by means of a flat ribbon cable. Requires 12 volts dc, and comes with mounting brackets and hardware. Address: Controls/Inc., Box 522, Consumer Sales Dept. 17, Logansport, IN 46947.

DBX SIGNAL PROCESSOR

The Model 128 signal processor by dbx contains a two-channel record/playback noise reduction system similar to the dbx Model 122, and a 2:1 dynamic range enhancement providing linear compression and expansion. The noise-reduction system is said to provide 30 dB of noise reduction and 10 dB headroom improvement when used for live recording and to prevent hiss and noise build-up when copying previously recorded material off a disc or tape. The dynamic range enhancement section offers restoration up to 20 dB of the

POPULAR ELECTRONICS

The Black Watch Kit \$19.95



THE KIT CONTAINS

1. printed circuit boards
 2. integrated circuits
 3. encapsulated quartz crystals
 4. trimmers
 5. capacitors
 6. LED displays
 7. 2-part case with window in positions
 8. batteries
 9. battery-clip
 10. black strap (black stainless-steel bracelet optional extra — see order form.)
 11. full instructions for building and use.
- All you provide is a fine soldering iron and a pair of cutters.

The Black Watch Kit by Sinclair is unique. Controlled by a quartz crystal...powered by two hearing aid batteries. Styled in understated elegance the Sinclair way. No knobs no buttons. To see the exact time or date just touch the face of the case. A re-set control is on the back.

Dimensions: 1-1/2" X 1" X 3/10"
 Weight: 1/2 ounce
 Strap: 3/4" wide
 Case: Specially designed unbreakable black matte plastic. Water resistant.
 Batteries: Mallory RM41H
 Accuracy: On a built watch we guarantee accuracy within a second a day. In building it yourself you may be able to adjust the trimmer to achieve an accuracy within a second a week.



sinclair (Actual Size)

Scientific Calculator Kit \$14.95



KIT COMPONENTS

1. Coil
2. LSI chip
3. Interface chips
4. Printed circuit board
5. Keyboard panel
6. Electronic components pack
7. Battery assembly and on/off switch
8. Case moldings, with buttons windows and light-up/display in position. Soft carrying case
9. Comprehensive instructions
10. Assemble time is approximately 3 hours.

Designing the Sinclair Scientific was no small feat of engineering, but you don't have to be an engineer to assemble it with our kit.

You can put together the world's most remarkable scientific calculator from eight groups of components, using only a soldering iron and a pair of cutters. (Complete instructions are included.) Less than 3/4-inch thin and 3-3/4 ounces light. British-made Sinclair Scientific isn't just portable, it's pocketable.

All parts are tested before shipment — and we guarantee any correctly assembled calculator for one year.

Features of the Sinclair Scientific

FUNCTIONS SUMMARY —

Algebraic logic
 Five function memory
 Sine, cosine, tangent, arcsine, arccosine, arctangent
 Degrees/radians switch
 Ln and e^x
 Square root, pi and reciprocal
 8 digit mantissa, plus 2 digit exponent
 Automatic constant
 Pocket-sized. 4-1/3" X 2" X 11/16".
 Weight: 4 ounces.
 Battery life. Low-cost, disposable AAA batteries (not included) operate for around 25 hours of continuous use.

1. **FREE TRIAL OFFER** If you decide not to keep and assemble your kit, you may return it undamaged within 10 days for a refund of its purchase price.

2. **SERVICE** If a problem arises in building your kit, Sinclair Service Department will fix it for you at a nominal charge.

3. **WARRANTY** Your correctly assembled kit will be repaired or replaced by Sinclair if it fails to operate within one year of purchase free of charge (except in the case of misuse).

4. To order your kit, just use the coupon and mail it with your check or money order to: GFN Industries, Inc., 6 Commercial Street, Hicksville, New York 11801.

To: GFN INDUSTRIES, INC., 6 Commercial Street, Hicksville, New York 11801

Black Watch Kit(s) at \$19.95\$
 Black Watch Kit(s) with stainless steel band at \$24.95
 Scientific Calculator Kit(s) at \$14.95
 Assembled Black Watch(es) with stainless steel band at \$39.95
 Assembled Scientific Calculator(s) at \$19.95
 Sales Tax (N.Y. Residents)
 Shipping and handling (\$2.00 PER UNIT)
 Enclosed is check/MO (payable to GFN Industries Inc.)
 TOTAL\$

NAME

ADDRESS

CITY STATE ZIP

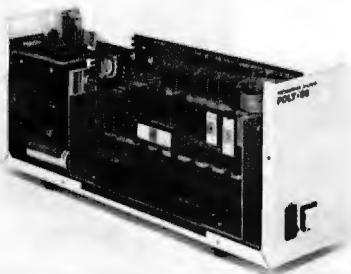
Quantity discount: For 6 or more units, the total shipping and handling charge is \$5.00.

KEY # PE-10WC

THE POLY 88 MICROCOMPUTER

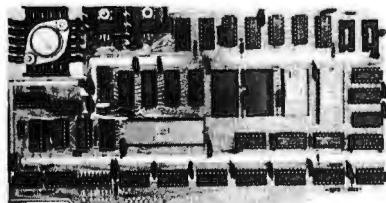
A Complete Microcomputer System
with Keyboard Input and Video Output

The Hardware: The heart of the POLY 88 microcomputer, the CPU circuit card, features an 8080A central processor, 512-byte RAM, space for 3K of PROM, vectored interrupt and real time clock, a dual serial port with software-selectable baud rate, and single-step logic



that allows the processor to execute one instruction at a time.

The POLY 88 also includes our video terminal interface circuit card, which is both a video display device and an input port for a keyboard. Sixteen lines of up to 64 characters may be displayed on a standard TV monitor or modified receiver. In addition to the 128 ASCII characters



which are displayed in an easy-to-read 7 x 9 font, there are 64 graphics characters available for plotting on a 48 x 128 contiguous grid.

These two circuit cards fit into a compact "Altair-compatible" chassis with room for up to five cards. A 6 amp power supply is built right on the mother board. The front panel consists of just two switches, on/off and reset; the monitor software with video screen and keyboard eliminates the need for a hardware front panel. As your system grows, you can plug chassis together for easy expansion. (The expansion connector also eliminates the need for an extender card.) Cassette, RS-232, and current loop interfaces are available which connect via ribbon cable to CPU board and mount on backpanel.

The Software: Supplied with the POLY 88 microcomputer is a 1024-byte monitor on ROM. The program is there when the power is turned on, so you don't need to key in a loader. The monitor is designed to use a keyboard entry and TV display, with a cassette or paper tape as the storage medium.

With the monitor you can: load data into memory in hex, display memory in hex, dump or read data from a storage device, and execute program one step at a time, displaying the contents of each of the 8080 registers as well as the values in memory at the address of each of the

A	F	B	C	D	E	H	L	SP	PC
3BC3	0DF0	0CFF	0C80	0CFF	0C01				
(BC)	C3	3B	F0	0D	FF	0C	00	0C	
(DE)	0D	21	00	00	75	23	7C	FE	
(HL)	00	00	00	00	00	00	00	00	
(SP)	0D	21	00	00	75	23	7C	FE	
(PC)	00	00	00	41	00	06	00	78	
.C80V									
0C00	00	00	00	00	41	00	06	00	
0C08	78	01	00	20	CD	4D	0C	00	
0C10	47	36	A0	19	36	8E	3E	20	
0C18	A5	C4	25	0C	3E	03	A4	CC	
0C20	30	0C	C3	00	0C	70	07	3F	
0C28	1F	DA	32	0C	01	02	00	C3	
0C30	40	0C	01	FE	FF	C3	40	0C	

registers. All of these functions are available the instant you turn on the power.

Future software available with this system will include BASIC, an assembler, and games.

Prices: Basic kit including chassis, CPU and video cards — \$595, \$795 assembled. Cassette option — \$90 kit and \$125 assembled. 8K of RAM — \$300 in kit form or \$375 assembled. We also sell the video and other "Altair-compatible" circuit cards separately.

Dealers: This system sells itself.

All prices and specifications subject to change without notice. Prices are USA only. California residents add 6% sales tax. Prepaid orders shipped postpaid. BankAmericard and Master Charge

- ☐ Please send more information
☐ Order and check enclosed

Name _____

Address _____

BankAmericard _____

Master Charge _____

**PolyMorphic
Systems**

737 S. Kellogg, Goleta, CA 93017 (805) 967-2351



dynamic range of an original performance that has been previously recorded. The two sections can be used independently or in tandem by means of front panel switching.

CIRCLE NO. 96 ON FREE INFORMATION CARD

SONAB BELT-DRIVE TURNTABLE

The Sonab Model 67S is a new Swedish manual record turntable offering two operating speeds (33-1/3 and 45 rpm). A 24-pole synchronous motor drives a 2.7-lb (1.2-kg) nonmagnetic platter through a belt. Wow is said to be less than 0.08% (DIN), and rumble better than 60 dB down. Its tonearm has a needle-and-ball-bearing support system, and can be used with cart-



ridges weighing from 4 to 12 grams. Other features include an onboard spirit level and adjustable feet for leveling adjustments, oil-damped manual cueing, a lightweight cartridge shell and adjustable weights for tracking force and antiskating adjustments. Connecting lead capacitance is 100 pF maximum. Measures 17" x 14" x 5" (435 x 350 x 150 mm), and weighs 15.5 lb (7 kg). Supplied with dust cover. \$240.

CIRCLE NO. 97 ON FREE INFORMATION CARD

DIGITAL TURNTABLE STROBE

Woodard Electric's Digital Strobe is a crystal-controlled electronic device for the measurement of turntable speeds (16-2/3, 33-1/3, and 45 rpm). A three-digit, seven-



segment readout enables the user to detect variations as low as $\pm 0.01\%$ in turntable speed. It can be adapted to the measurement of tape recorder speeds, and can be used for continuous monitoring without interference to normal turntable or tape deck operation. Address: Woodard Electric, Inc., Box 1050, Hartselle, AL 35640.

look up to Realistic!®

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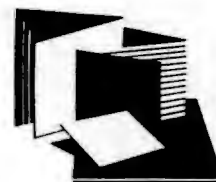
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New Literature

ELECTRONICS DESIGN AND TESTING

"59 Ways to Save Time and Money Designing and Testing in Electronics" is a new, 32-page, full-color, pocket-size catalog from Continental Specialties. Designed for electronics hobbyists, technicians and designers, the catalog features some of Continental Specialties' new items (a precision digital pulse generator, a selective-threshold test instrument that indicates logic status, and a circuit-powered, multi-function test tool with memory). There are also sections with helpful hints on the use of solderless breadboarding sockets and breadboards; a section on digital and linear breadboarding design and construction; and a block diagram and connection chart of the most popular digital IC's. Address: Continental Specialties Corp., 44 Kendall St., P.O. Box 1942, New Haven, CN 06509.

ELECTRONIC CIRCUIT HARDWARE

AP Products announces its new 19-page booklet on state-of-the-art breadboarding and testing devices. Included are AP's All-Circuit Evaluator series, designed to give greater flexibility and reliability to circuit building; IC test clips; strips; breadboards; uncards; pc extender cards; tie-point blocks; accessories, patch cords; miniature 8-pin connectors; connector pins and sockets; male and female headers; and digital test probes. The catalog is fully illustrated and technical specifications, dimension and application information are provided. Address: AP Products, Inc., Box 110, 72 Corwin Dr., Painesville, OH 44077.

CASSETTE TAPE BOOKLET

Fuji announces a new booklet, "Cassette Tape and How to Make it Work for You." Written on a nontechnical level, the booklet contains information on the selection and use of cassette recorders/players. It features a section describing the uses of cassettes as creative aides and explains the steps to take to ensure optimum results. Also included is a section on the language of cassette tapes, converting technical engineering language into understandable terms for consumers. Address: Fuji Photo Film U.S.A., Inc., Audio Tape Div., Empire State Building, New York, NY 10001.

CB ACCESSORIES CATALOGS

Turner announces new catalogs for its Citizens Band products. A 12-page micro-POPULAR ELECTRONICS



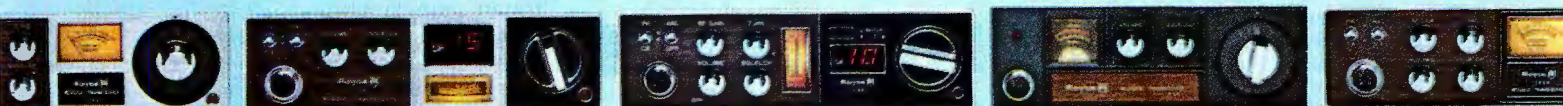
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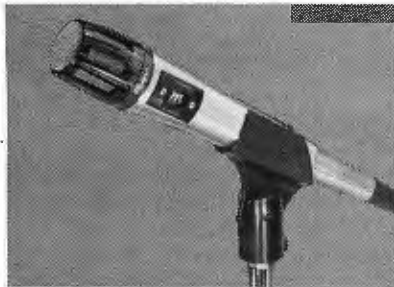
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Manufacturers of high fidelity components, microphones, sound systems and related circuitry.

phone catalog features seven new products, including an amplified base-station mike with tone-control and voice-strength meter, and an amplifier mobile microphone that uses readily accessible 9-volt batteries. Also available is the new Signal Kicker antenna catalog, which has been expanded to 16 pages, including a section on recreational vehicle antennas. Address: Turner Division of Conrac Corp., 716 Oakland Rd. N.E., Cedar Rapids, IA 52402.

1976 SEMICONDUCTOR GUIDE

General Electric announces a new 200-page 1976 edition of its Semiconductor Guide, ETRM-4311. The revised and updated catalog cross-references GE universal replacement semiconductors and supplies application and technical data on the devices. Included are 52 new entertainment semiconductor devices for TV, FM and FM stereo applications, and information on five semiconductor kits, 19 experimenter/hobbyist components and 22 accessories such as transistor heat sinks, sockets and micas, and IC sockets. \$1.00. Address: General Electric, Suite 301, 2001 Gardiner Lane, Louisville, KY 40205.

POLYPHONY

PAIA announces a new quarterly magazine "Polyphony." Directed toward the electronic music enthusiast, the publication intends to be an information exchange between the related fields of electronic theory and circuit design, music theory, acoustics and recording techniques. Containing reader contributions, PAIA staff material and new product information, the magazine combines the information into a usable format for electronic music applications. Current issue free upon request. Address: "Polyphony," % PAIA Electronics, Inc., 1020 W. Wilshire Blvd., Oklahoma City, OK 73116.

CB CATALOG SERIES

A new, 11-page catalog from Shakespeare illustrates its line of citizens, marine and business band antennas with related mounts, hardware and test equipment. Included are fiberglass whip, base-loaded, top-loaded, co-phased, and new 2-foot stick mobile antennas; half-wave omnidirectional CB base station antennas including the first fiberglass directional antenna; vhf-FM and SSB marine antennas; and mobile, base station and ground plane business band antennas. A section on mobile CB mounts and accessories and marine accessories is also included. In addition, Shakespeare offers a series of illustrated minicatalogues, featuring CB mobile transceivers; CB antennas and accessories; and marine antennas and accessories. Address: Shakespeare Co., 2805 Millwood Ave., Columbia, SC 29205.

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Stereo Scene

By Ralph Hodges

CONSUMER ELECTRONICS SHOW—SUMMER 1976

THIS YEAR'S SUMMER Consumer Electronics Show was orderly and level-headed. Among the majors—Pioneer, Marantz, Kenwood, Sansui, etc.—there were precious few introductions of top-of-the-line models, but there were scads of lower-price components to continue a series begun last year with one or two "flag-ship" products. This was especially true for receivers and integrated amplifiers, and even for some preamplifiers and power amplifiers. For example, Yamaha's premier introduction was the Model B-2 at 100 watts per channel. It is a V-FET power amplifier cast from the mold of the more powerful B-1. The Luxman 5M21, with the same power rating, is obviously a descendent of that company's larger power amplifiers. In addition, both manufacturers introduced companion preamplifiers at lower prices than heretofore.

Trends & Themes. It was a banner show for direct-drive turntables—to the point where it is a rare major turntable line that does not include at least one. The elite among the direct-drives now derive their reference frequencies from quartz-crystal oscillators, and their servos employ phase-locked loops. Technics, JVC, and Sansui all had brand-new machines with these features at CES.

Apparently the market for three-head cassette decks is suddenly coming to life once again. It seems that a

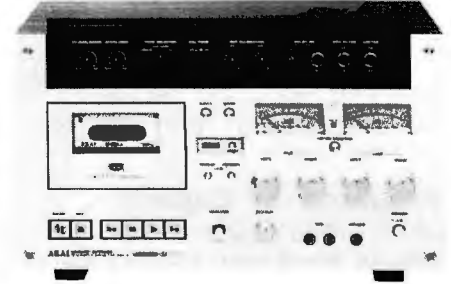
serious tape-alignment problem has balked the widespread availability of such machines up to now. The problem has been that any significant spacing between the record and playback heads gives the cassette's relatively crude tape-guidance system ample chance to skew the tape. And since no cassette is (in theory) exactly like any other, there was no predicting what sort of azimuth error the skew would introduce. Even turning a cassette over to use its other side would often significantly alter the alignment.

The Models 1000 and 700 from Nakamichi, now a few years old, incorporated the first practical remedy for this state of affairs: an alignment "beacon" system that enabled one to reset the azimuth of the record head quickly and unambiguously for each cassette side. Then, last year, Hitachi presented a deck, the D/3500, with a wholly new approach—record and play heads that snuggled against each other so closely that any tape skew within the short space separating the two sets of gaps was a scant possibility. In fact, the gaps were so close they could even share the cassette's single pressure pad. Apparently, this innovation lent impetus to other cassette-deck manufacturers who had thought that azimuth adjustments were a bit too arcane and expensive to attract an appreciable market. Fisher acted first, and now has three models employing this scheme. Akai has used it for its new GXC-570D, among other machines. And now this year, Teac has adopted it for its long-anticipated three-header, the 860, which will head the company's brand new "Esoteric" series. In place of azimuth adjustments, the 860 has continuously variable bias and equalization controls on its front panel, as well as elaborate mixing facilities.

A few manufacturers have elected to stick with separate, spaced record and playback heads. Among them are

Tandberg, whose new TCD 330 has a record-head azimuth adjustment with a meter to indicate correct alignment. The Lenco C-2003 also has spaced heads, but seems to lack any special alignment features.

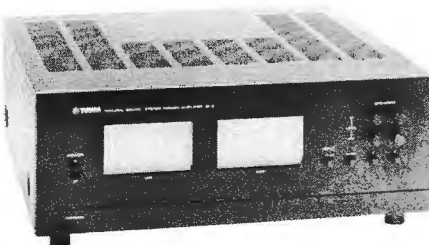
In the world of loudspeakers, the CES brought a small inundation of products designed to be phase-coherent, following the lead provided (in their various manners) by Ohm, Dahlquist, and B & O. The most popular approach is obviously the staggered-array configuration. In other words, if the tweeter is a little "faster" than the woofer in getting off the mark, simply locate the tweeter's diaphragm a little farther from the listener to even things out. This results in staggered drivers, each occupying its own mounting plane. The B & W DM6 from England is a good example, as is a new floor-standing system from Eng-



Akai GXC-570D cassette deck.

land's KEF. From the U.S., the Audioanalyst "Anthem Array," the Jennings Research Contrara Vector One, and the Paradox TA-12 "Time Align" (highly reminiscent of the B & W product in its appearance) are all adherents of this philosophy. Even Japan demonstrated interest via the "Professional Series" from Technics by Panasonic. The top-of-the-series model, the SC-9000, is truly a sight to behold, with four large woofers and three enormous mid- and high-frequency horns, looking powerful enough to be lethal to houseflies and other frail life forms.

New amps or old? You've probably noticed a trend to Class A amplifiers from some manufacturers of the more esoteric electronic products. This was continued by new CES products from Stax, Mark Levinson, and some other lesser-known companies. The claimed benefits and the performance of such devices have been tempting to consumers and other manufacturers alike. However, the reduced gain and comparative inefficiency of Class-A



Yamaha B-2 power amplifier.



TC-800GL

HP-1

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you don't like to do a lot of fiddling around, both models offer automatic convenience features like Auto Timer Start, Auto Stop, Auto Memory Rewind, and Auto Switching for CrO₂ tape.

Also showing Mr. Bellini's touch, the functional wedge styling and stepped controls of these cassette decks give you easy control and visibility from any standing, sitting, or reclining position.

If you'd like a closer look at some other examples of form following function, send for our free catalog of stereo components. Or see your local Yamaha Audio Specialty Dealer. You'll get a lot more than just a demonstration.

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operation have made the whole idea seem impractical in a power-competitive market. Class AB or something close to it has therefore remained supreme up to now. But CES gave evidence that some designers are out to get the best of both worlds.

In the SR/903 receiver, Hitachi presented the first example I have personally encountered of a Class-G amplifier. Briefly, the equivalent of two

Audionics PZ3, is also said to use a bias-shifting control circuit.

The Elcaset. CES served as the official debut arena of the Elcaset format, for which its co-developers, Matsushita (Panasonic and Technics), Sony, and Teac, have high hopes. The Elcaset principally differs from the Philips cassette in being considerably larger, using 1/4-inch tape and a 3 3/4-ips tape speed. Also, it does not depend

which room is provided in the center of the Elcaset tape).

No one doubts that the Elcaset format can measurably outperform the Philips cassette. But the big question being asked is: Will this measurable superiority translate to a significant *audible* superiority? In other words, is it possible that the Philips cassette format, over its years of refinement, has become good enough to compete with any other high-fidelity program source—the Elcaset and even high-speed open-reel—for certain types of program material? And if it hasn't, isn't it likely to in the near future, obviating the need for another quality tape cassette format at this time?

The coming months should yield some answers to these questions. In the meantime, it is true that the Elcaset doesn't face the restrictions on four-channel that have troubled the Philips cassette. But if this is to be a factor, we then have to ask whether the apparently waning interest in quadraphonics will justify any manufacturer's offering a four-channel Elcaset machine.

A final question being asked about the Elcaset format concerns the tape itself. Who is going to be supplying Elcaset, and in what form? Sony is into production already, of course, and will be offering a low-noise tape



Hitachi SR 903 receiver.

push-pull output sections is employed. One handles small amplitude signals and the other is switched in for large transients. If I understand the whole business correctly (details were still sketchy at showtime), the two sections are biased differently, enabling the low-output section to approach Class-A operation, and the high-output section to operate in a very efficient mode. The idea recalls to mind the Sharma circuit from the Mattes amplifier of the mid 60's, although the actual configuration of the circuit is, of course, different. At 75 watts per channel continuous, the Hitachi receiver is not a powerhouse by today's standards, but the power it does have comes in a competitively sized and priced package, with some intriguing technical features.

The Nakamichi 620, a 100-watt-per-channel power amplifier, is said to operate—I am tempted to say “nominally” operate—in the Class-B mode. Of course Class B, efficient though it is, can be beset by crossover distortion and other troubles if the designer is not very careful. But this amplifier has a 0.005 percent *guaranteed* distortion level. Apparently (again details were few at the moment of writing) the nastinesses of Class B have been cured by a carefully designed bias-control circuit. In any case, the 620 is certainly compact enough to support its claims for highly efficient operation and only two transistors per channel are used in the output stage. Another amplifier introduced at the show, the

on the cassette package itself to provide tape guidance. Instead, the tape is drawn out of the cassette in the form of a loop, so that the machine's internal guides and tensioners are solely responsible for its transport and alignment.

In these respects, the Elcaset resembles the BASF Unisette announced last year, but as yet not really seen in this country. However, while the Unisette envisioned professional users, the Elcaset is intended as a consumer product.

The CES brought forth four machines that can record and play Elcaset: the Sony EL-7 and EL-5, a deluxe Technics, and a Teac prototype. The Sony decks were three-head three-motor (the EL-7) and two-head single-motor (the EL-5). The Technics extravaganza had four direct-drive motors (two in the dual-capstan tape-drive system) and four heads (the fourth for the narrow control tracks for



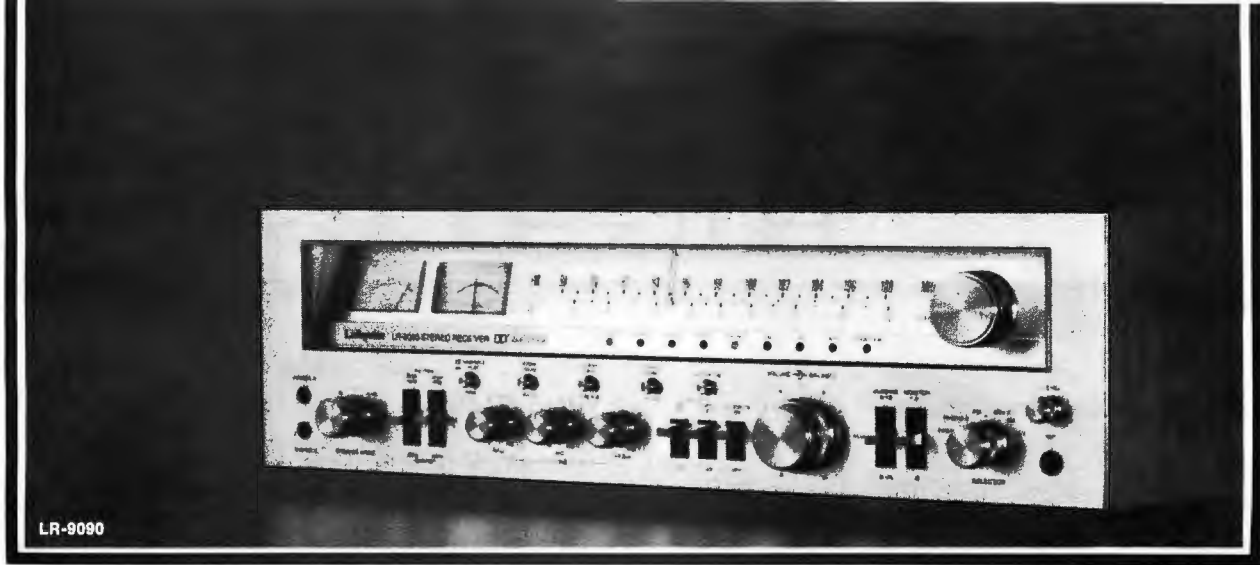
Luxman 5M21 power amplifier.

formulation as well as Ferrichrome (the first 1/4-inch Ferrichrome tape to appear on the market). The positions of the other tape manufacturers have not been clarified, however. Another matter: the Technics machine has switch positions for chromium-dioxide bias and equalization, although Sony has not announced a chromium-dioxide Elcaset and at the moment there seems to be some doubt whether it will. To what extent might the Elcaset format get embroiled in the chrome-vs.-ferric debate that is being waged rather briskly right now?

Whatever happens, the Elcaset promises to be a superb if rather expensive tape medium. But certainly it will not be beloved by all. Some manufacturers are talking about serious ventures into microcassettes. If they make a move, things should really be jumping by this time next year. ♦



Teac 860 cassette deck.



The new Powerhouse line. It's only competition is on this page.

No one can compete with Lafayette's new Powerhouse line of receivers.

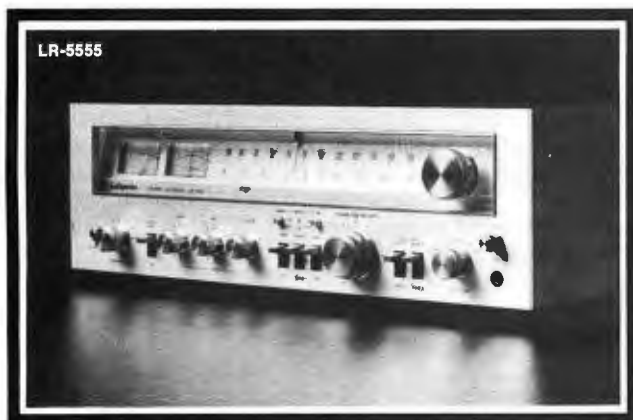
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The two top of the line receivers have features you've never had on any receiver before. Advanced features like Dolby® FM noise reduction system (on the LR-9090) and a mike mixing feature on both models. Even features like mid-range frequency emphasis and tape dubbing controls are included

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Specifications	LR-9090	LR-5555
Power Min. RMS 20-20,000 Hz	90+90	55+55
Total Harmonic Distortion(Less Than)	0.1%	0.5%
Input Sensitivity: Phono/Aux/Mike mV	2.5/150/6	2.5/150/6
Tone	Bass/Mid/Treble	Bass/Mid/Treble
Speakers	A, B, C	A, B, C
FM Sensitivity (Stereo)	21.0 dBf (1.8 μ V)**	21.0 dBf (1.8 μ V)**
Selectivity	80 dB	80 dB
Capture Ratio	1.25 dB	1.25 dB
Price	\$599.95	\$399.95

* @ 40-20,000 Hz
** IHF ('58) Sensitivity (Mono)

Lafayette

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news

HIGHLIGHTS

CB Channel Expansion, Etc.

The FCC will add 17 AM voice channels to the present 23 on the 27-MHz CB radio band, effective January 1, 1977. Technical specification requirements will change, too, with spurious response requirements more stringent. Receivers with 40 voice-communication channels won't be available very soon, however, since the equipment must be type accepted by the FCC (which recently rejected 25 applications for certification of 23-channel rigs). Then there are production and distribution to be taken care of. Moreover, there won't be many people to talk to on the 17 new channels for some time to come. Additionally, truckers are expected to continue to use Channel 19, while Channel 9 will remain as the emergency/assist channel. So the 23-channel CB transceiver promises to be with us for some time, just as vhf television hasn't been supplanted by the addition of uhf stations.

Among other rulings, Channel 11 is no longer the CB "calling channel." It will be used just as other allocated frequencies (except Channel 9, of course). And CB'ers will not be able to blithely ignore harmonic interference to a neighbor's television receiver (Channels 2, 5 or 6) due to insufficient harmonic suppression. The licensee causing the interference is now directed to insert a low-pass filter between his r-f output connector and the antenna feedline. Furthermore, a host of proposed changes were shot down. For example, the present 27-MHz Class C radio control frequencies will not be reallocated to the Class D band, although the FCC indicated that alternate frequencies must be found at some time due to the problem of interference to Class C operations. Also, a proposal to lower the age requirement for a Class D station license from 18 to 16 has been turned down for now.

Test Cassette Series

A new series of cassette tapes for test purposes has been introduced by TDK. The "AC" series consists of 12 cassettes for testing crosstalk, recording calibration, head alignment, frequency characteristics, wow and flutter, tape speed, and playback calibration with and without Dolby. Cassettes range in price from \$10 to \$35 each.

Needle-Fine Solder

Solder with 5 rosin cores, capable of fitting through the eye of a needle (a one-pound reel of 34 SWG is nearly one mile long), has been developed by Multicore Solders of Westbury, New York. Designed for integrated circuit, miniature component and micro-electronic applications, the extremely fine solder makes it easier to control the placement, amount and speed of soldering.

Video Game Chip Shortage

The rising demand for home video game IC's and MPU's was evident this year at the Summer Consumer Electronics Show, where a number of toy manufacturers and electronics companies displayed their games. It's estimated that the total number of video games sold this year will range from two to five million. Most suppliers expect, however, that the demand will continue to outstep the supplies, pushing manufacturers farther back in their delivery schedules. Though the parts shortage is expected to be temporary, supplies promise to be tight through the pre-Christmas season.

Computers At Golf Classic

For the first time, the R and A Golf Club of St. Andrews, Scotland employed computer terminals to improve spectator information on scores at the 105th British Open Championship held in Southport, England this summer. The terminals, supplied by Sperry Univac, automatically relayed scoring information throughout the club for printout and scoreboard posting. Ultimately, the goal of the R and A Club is to use a computer which can provide detailed information on the progress of the championship tournaments, as well as historical statistics and analyses of the players' performances hole-by-hole.

AM Stereo Broadcasts

Kahn Communications, Inc. has filed a petition with the FCC to institute proceedings for a change in regulations which would allow AM broadcasters to operate stereophonically. The petition stresses that the system is compatible with standard AM broadcasting, that it covers large reception areas, and does not contain the noise bursts found in FM stereo automobile reception, and that many listeners already own radios that can receive the AM stereo signal. Reports have been submitted to the FCC by WFBR, Baltimore and XETRA, Tijuana, Mexico concerning on-the-air experiments that have been made over a total of three and a half years.

PSB Frequency Assistance

To help owners of vhf/FM monitors and scanners learn which frequencies are used in their reception areas, the Electra Company has established a Frequency Assistance telephone line to serve their customers in most areas of the U.S. It's open each working day from 8 a.m. to 5 p.m., and can be reached by calling, toll free, 800-428-2326 (in Indiana 800-382-2072).



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Shakespeare CB units are a cut above the ordinary. Engineered better to be the best.

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The GBS/1500 solid-state transceiver utilizes Shakespeare's advanced circuitry and design to assure optimum clarity with reduced interference.

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Sea tough. Highway dependable.

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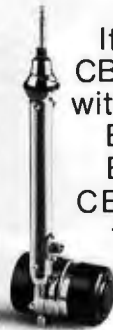
Switch to the CB antenna that beats the Citizens Bandits.



**Now you
see it.**



**Now they
don't.**



It's no wonder people are worried about CB thefts. All a thief has to do is spot a car with a CB antenna and he has his target.

But he can't spot ours.

Because the TennaPower Disappearing CB Electric Antenna hides inside the fender when it isn't being used.

But there's no hiding from it when it's up. Because it performs like gangbusters.

One flick of the switch extends it fully or drops it out of sight. And even turns your transceiver's power on or off, automatically, at the same time.

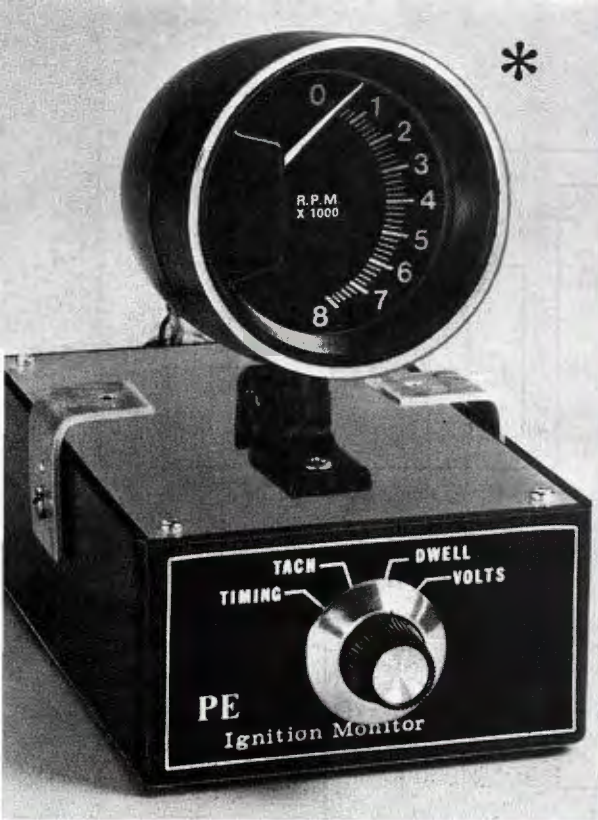
Our antenna is center-loaded for better range. Its unique "skinny" coil disappears into the fender. Our motor is lifetime lubricated. Our materials are virtually corrosion-proof. And the antenna is designed to obtain an optimum SWR of 1.5:1 or better.

And our Disappearing CB Electric Antenna gives you this big, exclusive advantage: it's made by Tenna. We're the world leader in electric car antennas. Because we've built over 5 million disappearing electric car radio antennas for GM, Ford, Chrysler and Rolls Royce.

So buy the TennaPower Disappearing CB Electric Antenna at a dealer near you who sells CB or car stereo. You can ask him about installation or you may want to do it yourself.

Then beat the Citizens Bandits with the CB antenna thieves can't see. We think you can see why.

**Tenna
Corporation** 
Cleveland, Ohio 44128



Build a CAR IGNITION MONITOR

Provides a visual indication of timing angle, rpm, dwell, and system dc voltage while you drive.

BY WALTER B. HENRY

WITH THE high cost of gasoline and annual increases in new car prices, it is becoming increasingly more important to keep our cars in perfect tune for maximum economy and engine life. Unfortunately, most of us put off periodic checks until our cars get "sick" and force us to do something about them. Hence, what every car needs is a device that keeps tabs on ignition performance at all times and provides a warning of potential problems before the car breaks down. This is exactly what the full-time Ignition Monitor described here is designed to do.

The Ignition Monitor lets you make all the common ignition system checks simply by flipping a switch and glancing at a meter. The parameters the system is designed to check include: ignition timing angle in degrees BTC, rpm, dwell angle, and electrical system voltage. The monitor can be permanently mounted in your car so that these parameters can be checked under all driving conditions—not just at idle. It can also be built into a handheld case for tuning other cars equipped with the necessary sensor.

The system can be used with any 4-, 6-, or 8-cylinder engine equipped with either conventional (Kettering) or electronic ignition systems with breaker-point, magnetic, or optical switching. It can even be used with most magneto systems. An inexpensive accessory tachometer is used as

**Tachometer is not included in kit given in Parts List.*

the system's parameter indicator, while the electronics package is housed in a separate box that mounts under the dashboard.

Once your car is properly tuned and the Ignition Monitor is installed, you will soon get a "feel" for detecting even subtle changes in ignition operation. By monitoring the timing meter and driving for maximum advance, you can stretch your gas mileage and begin to economize immediately.

How It Works. The timing circuit of the ignition monitor utilizes an infrared LED/phototransistor optoelectronic sensor that senses a reference position of the engine's crankshaft. The sensor mounts close to the front pulley, or harmonic balancer. Once each crankshaft revolution a small metal "flag" attached to the pulley passes through the sensor and interrupts the infrared beam. This generates a signal that precisely indicates the position of the crankshaft.

In the circuit shown in Fig. 1, IC1A forms a flip-flop. Interruption of crankshaft sensor current causes the flip-flop to turn on. The subsequent arrival of an ignition pulse from the distributor terminal of the car's ignition coil triggers the shaping circuit made up of IC1B. The shaper output then turns off the flip-flop via D6 and resistor R28.

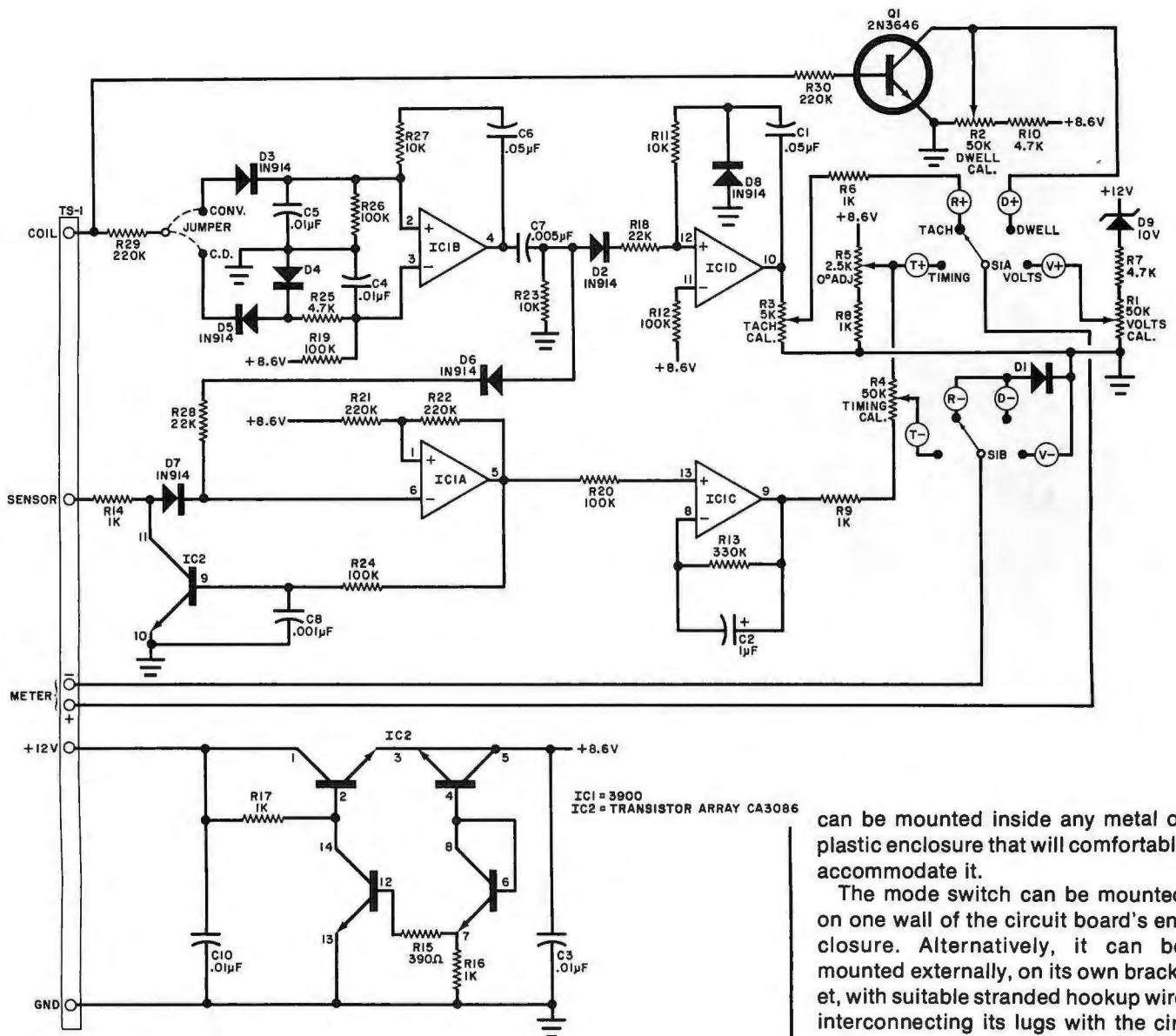
The output of the flip-flop is a series of pulses with a duty cycle that is inversely proportional to the timing angle. A smoothing circuit made up of

IC1C conditions the pulse train to drive the meter movement.

Most conventional and transistorized ignition systems have an initial positive pulse from the coil. This positive signal is routed to the IC1B shaper through a jumper in the IC1B input circuit. Most capacitive-discharge systems have an initial negative pulse output, which is routed through the C.D. side of the jumper.

The tachometer circuit uses a one-shot multivibrator circuit formed by IC1D. The constant-width pulse output from this stage has a duty cycle that is directly proportional to engine speed. The pulse output is smoothed by the inertia of the meter movement. Transistor Q1 delivers a pulse output whose duty cycle is proportional to the dwell angle. A 10-volt zener diode, D1, allows the meter to function as an expanded-scale volt-meter that registers potentials greater than 10 volts. Any potential less than 10 volts will not register on the meter.

Construction. You can assemble the entire circuit on perforated board or on a printed circuit board, the actual-size etching and drilling guide and components-placement diagram for which are shown in Fig. 2. There are two sets of connections to the circuit board. One set is via terminal strip TS1, which is for making connections to the car's ignition coil and electrical system, the sensor, and the meter. The other connections come from mode switch S1. the circuit board assembly



PARTS LIST

C1, C6—0.05- μ F, 100-V disc capacitor
 C2—1- μ F, 10-V electrolytic capacitor
 C3, C4, C5, C10—0.01- μ F, 100-V disc capacitor
 C7—0.005- μ F, 100-V disc capacitor
 C8—0.001- μ F, 100-V disc capacitor
 C9—Not used
 D1 through D8—1N914 diode
 D9—1N758 10-volt zener diode
 IC1—CA3401, LM3900N, or MC3401P quad operational amplifier
 IC2—CA3046, CA3086, LM3046, or LM3086 transistor array
 Q1—2N3646 transistor
 R1, R2, R4—50,000-ohm upright pc-type trimmer potentiometer
 R3—5000-ohm upright pc-type trimmer potentiometer
 R5—2500-ohm upright pc-type trimmer potentiometer
 The following resistors 1/4-watt, 10% tolerance:
 R6, R8, R9, R14, R16, R17—1000 ohms
 R7, R10, R25—4700 ohms

R11, R27—10,000 ohms
 R12, R19, R20, R23, R24, R26—100,000 ohms
 R13—330,000 ohms
 R15—390 ohms
 R18, R28—22,000 ohms
 R21, R22, R29, R30—220,000 ohms
 R31—680 ohms
 S1—Two-pole, four-position nonshorting rotary switch
 Sensor—GE Photo-coupled H13A1 or H13A2 module
 TS1—Six-lug screw-type terminal strip
 Misc.—Suitable metal enclosure (see text); control knob; tachometer (see text); stranded hookup wire for interconnections; metal shim stock for flag (see text); epoxy cement; spacers; machine hardware; solder; etc.
 Note: The following items are available from Kingston Instruments, 3805 Ashford Ave., Fort Worth, TX 76133: Etched and drilled printed circuit board for \$5.50; pc board with components and sensor for \$21.50; complete kit except for tachometer for \$26.50; sensor for \$3.00. Texas residents, please add 5% tax.

can be mounted inside any metal or plastic enclosure that will comfortably accommodate it.

The mode switch can be mounted on one wall of the circuit board's enclosure. Alternatively, it can be mounted externally, on its own bracket, with suitable stranded hookup wire interconnecting its lugs with the circuit board assembly.

Almost any electronic tachometer can be used for the display. The only requirement is that the meter movement can be driven to full-scale with 1 mA or less current. If the tachometer you buy has an electronic circuit in it, disconnect the circuit from the meter movement. Then solder a length of red stranded hookup wire to the movement's + terminal and a length of black stranded wire to the - terminal. Reassemble the tach's case, and terminate the free ends of the wires to the terminals labelled + (red) and (black) METER on TS1.

Different tachometer scales can be used in this application. For example, if you buy a tach with a 0-to-6000-rpm scale, it can indicate timing from 0° to 60° BTC, dwell from 0° to 60°, and voltage from 10 to 16 volts. A 0-to-8000-rpm tach will yield top-end figures of 80° BTC, 80°, and 18 volts, respectively.

The sensor must be mounted close

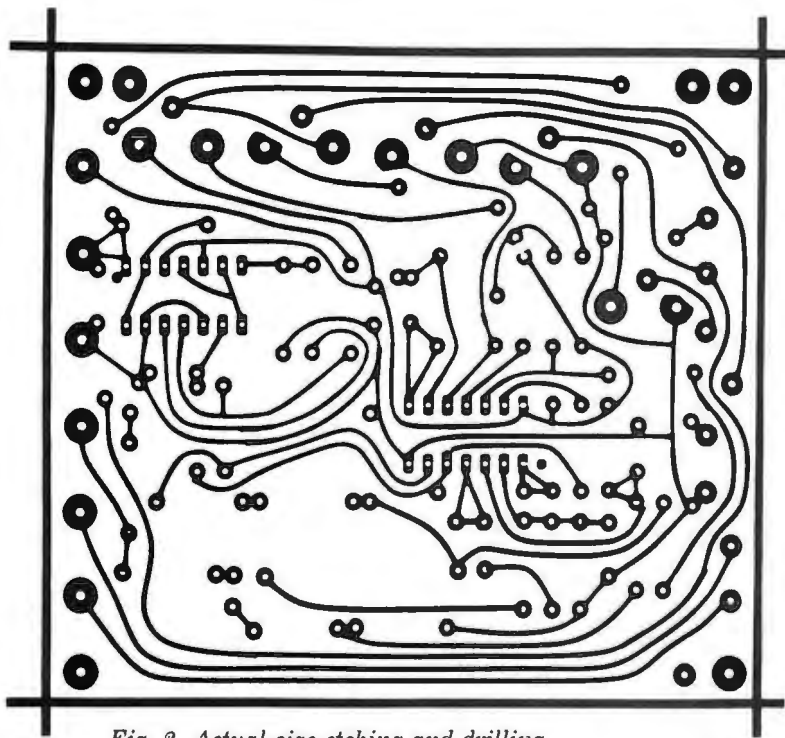
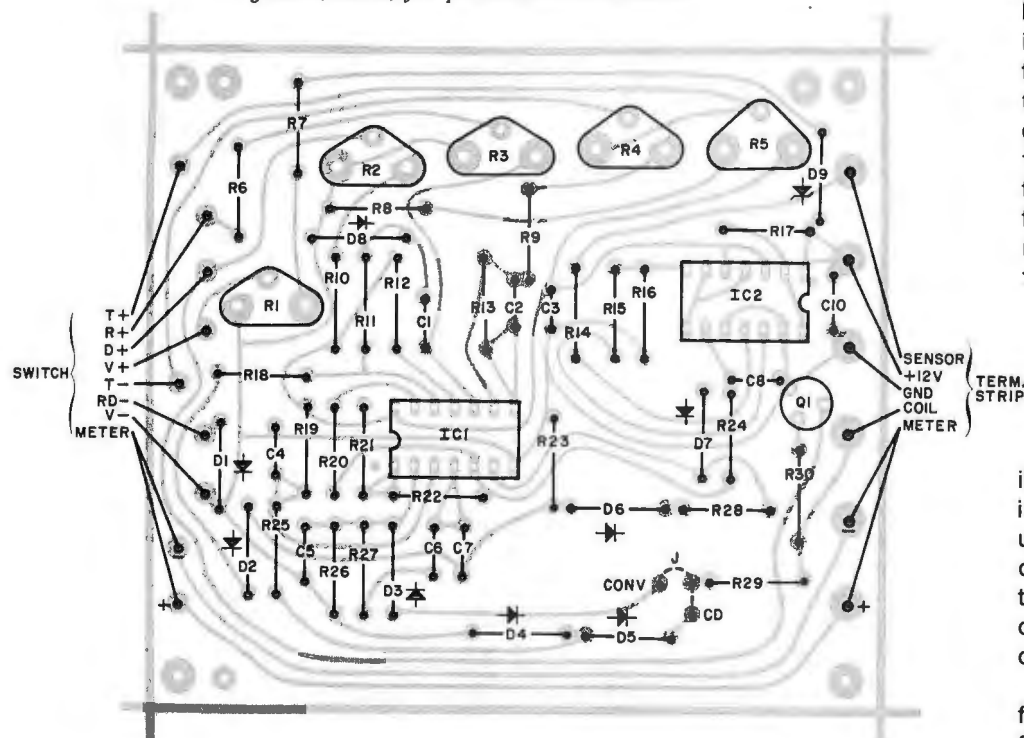


Fig. 2. Actual-size etching and drilling guide (above) and component placement guide (below) for printed circuit board.



to the front engine pulley, or harmonic balancer, as shown in Fig. 3. Fabricate a stiff metal bracket that will support the sensor with its gap facing toward and about $\frac{1}{4}$ " (6.4 mm) away from the pulley's rim. This mounting bracket can be mounted as required on a water-pump bolt, pan bolt, or any other rigid mounting point near the pulley. Make the mounting bracket as short and stiff as possible to eliminate any vibration. Then route the three sensor leads away from any hot areas

in the engine well and pass them through the firewall at a point near where the circuit board assembly's enclosure will be mounted inside the passenger compartment.

The sensor flag can be fabricated from thin aluminum or brass shim stock trimmed to about $\frac{5}{8}$ " \times $\frac{3}{16}$ " to $\frac{1}{4}$ " (15.9 \times 4.8 to 6.4 mm). Normally, about $\frac{1}{4}$ " of the flag's length will be glued to the rim of the pulley, leaving about $\frac{3}{8}$ " (9.5 mm) of its length protruding beyond the rim to pass through the

sensor's gap once with each revolution of the crankshaft. Anchor the flag to the pulley with epoxy or any other strong water- and oil-resistant cement.

To properly position the flag on the pulley, refer to Fig. 4 and use a large wrench to turn the engine so that the timing mark on the pulley exactly lines up with the 0° timing point. Measure as closely as possible a 73° angle from the sensor in the direction of pulley rotation and attach the flag at this point. (Alternatively, use the wrench to pull the engine through 73° against the direction of rotation and cement the flag so that it is centered in the gap of the sensor.) The angle can be measured with a protractor. Another way to measure the angle is to measure the circumference of the pulley, divide by five, and with the engine on the 0° mark measure the calculated distance from the sensor to the flag position. The angle is not critical, but it must fall between 68° and 78°.

Installation & Adjustments. The installation wiring of the system is detailed in Fig. 5. In conventional ignition systems, the coil lead goes to the distributor terminal. In electronic systems, it may be necessary to try both terminals to locate the "hot" one. (In factory-installed systems, it may be necessary to consult a service manual to determine the proper hookup point

if the coil is contained in a module or in the distributor assembly.) Do NOT under any circumstances connect the coil lead to the high-tension (spark) terminal of the coil; if you do, you will destroy the monitor and introduce a dangerous shock hazard.

Route the coil lead through the firewall, spacing it a few inches away from the bundled sensor leads to avoid having noise pulses causing erratic operation. Then wire in a ground lead and a separate +12-volt supply lead. The +12-volt line should go to a source in the car's electrical system that is live when cranking the engine but off when the ignition is switched off.

Connect the meter and power leads to the electronics package. For now, leave the sensor and coil leads unconnected. Also, leave the electronics subassembly box unmounted so that

the trimmer potentiometers are easily accessible.

Five adjustments are required for accurate operation of the Ignition Monitor. You will need a voltmeter, tachometer, and timing light. (For a 4-cylinder engine, you will also need a dwell-meter.) Make the adjustments according to the following sequence:

1. Set all trimmer potentiometers to midrange. Connect the meter and the power leads to the electronics box but leave the sensor and coil wires unconnected. Do not start the engine yet.

2. Set the mode switch to VOLTS. Use the voltmeter to measure the vehicle's supply voltage and adjust VOLTS CAL pot *R1* to obtain an identical

rpm reading. Check the calibration at various engine speeds. (Note: Accidental connection of the coil lead to the sensor input terminal may damage the IC's if the engine is started.)

5. Stop the engine. Connect the timing light and hook up the sensor leads to the monitor as shown in the wiring diagram. Loosen the distributor, disconnect the vacuum lines, and start the engine. Using the timing light, turn the distributor until the engine is timed at exactly 0° BTC. Then adjust 0° ADJ pot *R5* for a meter reading of exactly 0°.

6. Turn the distributor for the greatest advance that can be read on the engine timing marker with the timing light (usually about 16° to 20°). Then adjust TIMING CAL pot *R4* for the same reading on the meter. Recheck the 0° adjustment, and if it is not right on 0°, repeat steps 5 and 6.

7. This completes the adjustments. Set the timing back to the factory specification and reconnect the vacuum lines.

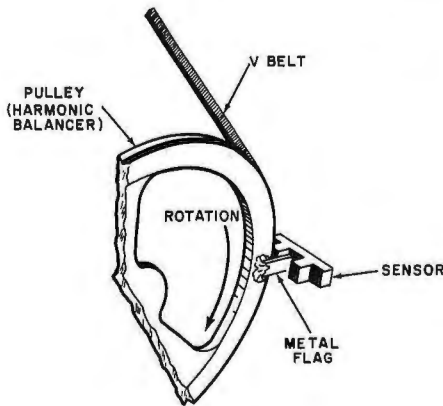


Fig. 3. Metal flag, 5/8 in. by 1/4 in. is attached to rim of harmonic balancer pulley to pass through slot in sensor interrupting light beam.

reading on the monitor's tach meter. Bear in mind that only potentials that exceed 10 volts will be indicated on the tach meter. (If the meter's pointer swings below the zero index, reverse the meter leads.)

3. Set the mode switch to DWELL. For an 8-cylinder engine, adjust DWELL CAL pot *R2* for a 45° reading; for a 6-cylinder engine, adjust for a 60° reading. For 4-cylinder engines, the adjustment must be made by comparison with a dwell-meter with the engine running. The correct reading here would be 90°, but most tachs will not have scales calibrated up to 9. Therefore, complete step 4 before making the 4-cylinder dwell adjustment.

4. Connect the reference tachometer and the coil lead to *TS1* and start the engine. For a 4-cylinder engine, connect the reference dwellmeter and adjust for an identical dwell reading. Set the mode switch to TACH and adjust TACH CAL pot *R3* for an identical

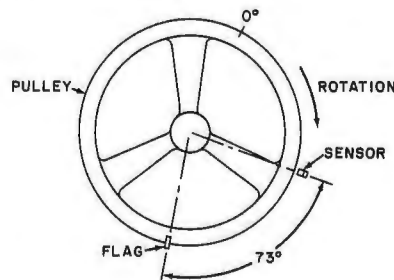


Fig. 4. Flag is positioned approximately 73 deg. from sensor when pulley is at 0-degree timing mark.

How To Use the Monitor. To get the most from your Ignition Monitor, we suggest that you make notes of ignition timing under different operating conditions. Do this when your car has been perfectly tuned, including a full distributor check. Make a note of timing at idle (on some engines, this depends on speed, vacuum, and engine temperature). By developing a feel for what to expect, you will quickly learn how to detect even subtle changes in engine performance.

Ignition timing specifications can be obtained from your car dealer and service manuals. Centrifugal advance and vacuum advance are normally specified separately. The engine can be run at various speeds with the vacuum lines disconnected to check centrifugal advance against the specs and then with the vacuum lines connected to determine vacuum advance. Make

sure that the dwell reading is steady. Jittery readings or sudden changes may indicate a worn distributor shaft. With most of the newer CD electronic ignition systems, the dwell reading is meaningless since current does not have to build up in the coil. In some systems, the dwell is electronically varied, depending on engine speed. In these cases, the manufacturer's specifications should always be consulted.

Some newer engines may have a negative timing angle under certain operating conditions (spark occurs after TDC). The Ignition Monitor will read down-scale from 0 under these conditions, but only until the pointer comes to the mechanical stop. Some newer cars, especially expensive foreign makes, come with voltmeters rather than the more common ammeter. In colder climates, proper voltage readings with the engine running and the battery charged should be 14 to 15 volts, while in hot weather, the reading should be 13 to 14 volts. The voltage regulator is designed to compensate for ambient temperature variations.

If you use your Ignition Monitor in more than one car, the flag must be properly placed by trial and error in each car. The 0° adjustment compensates for flag positioning on first car, so the flag on all other cars must be

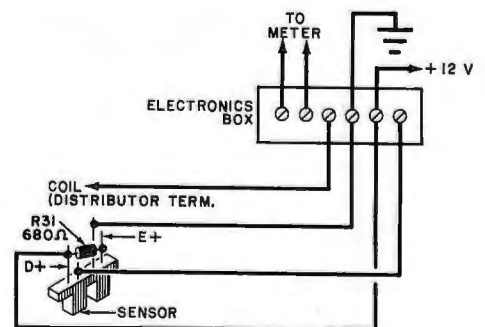


Fig. 5. External connections to the ignition monitor.

positioned in exactly the same manner. Keep in mind that small adjustments can be made by moving the sensor slightly, instead of moving the flag. We suggest that you permanently install a flag and sensor in each car with which the Ignition Monitor is to be used.

The Ignition Monitor has been designed for the serious auto enthusiast. When properly installed and used, it can help you diagnose engine problems and obtain optimum performance and economy.



A Digital Clock for Vehicles

Six-digit, crystal-controlled LED clock keeps accurate time in hostile environment.

CLOCKS with digital readouts are seemingly omnipresent today. However, you seldom see one in a car, camper, or boat. The clock project described here can change this. You can construct a low-cost 6-digit clock that is powered from a 12-volt dc source on anything from a pick-up truck to a cabin cruiser.

Obviously, such a clock is required to keep accurate time in a very hostile environment (including temperature extremes) and with a very noisy electrical supply. Also, since the clock must run continuously to maintain the correct time, it must require very little current. To avoid calling attention to itself when strangers look into an empty car or boat, the display should be darkened except when the ignition key is inserted. The mobile clock discussed in this article meets all of these requirements.

The 6-digit, 12-volt clock requires nominally 13 mA with the display off. Thus, if a 50-ampere-hour battery is used, battery life in excess of five months without recharging can be expected for the clock.

Circuit Operation. Timing for the clock (Fig. 1) is derived from a crystal-controlled oscillator operating at 6.5536 MHz. This is part of IC2. Also in IC2 is a 16-stage binary counter that delivers an output of 100 Hz at pin 1. Trimmer capacitor C5 is used to adjust the frequency (hence clock time keeping) for the desired accuracy. The 100-Hz output of IC2 drives a divide-by-two flip-flop in IC3 whose output at

pin 1 is 50 Hz, the frequency needed to drive clock chip IC1.

The clock chip contains the counting, dividing, display drive and multiplexing, and time-setting circuits. Some of the outputs energize the segments of the display, while others energize Q1 through Q6 to multiplex the display. Capacitor C1 and resistor R1 determine the multiplex frequency. Switch S1 controls the slow set and S2 controls the fast set.

Zener diodes D2 and D3 (with C2 and C3) protect the IC's from potentially damaging voltage spikes. They also eliminate false counting due to noise from the ignition. Diode D1 protects the circuit from wrong voltage connection.

Construction. Although any type of construction can be used, a printed circuit board (Fig. 2) is recommended to keep the size down. The IC's are protected against static discharge, but care must be used in handling and installing them.

Install all of the jumpers except for the one between IC1 pin 16 and IC3 pin 1. Then install all of the components as shown in Fig. 2. Be sure to observe the polarities on capacitors, diodes, and IC's. Sockets can be used for the IC's, if desired.

Solder a short length of bare wire into each hole in the bottom edge of the display board. The wire should protrude from the back side of the board and, after soldering, should be trimmed flush with the front side. Place the main board on a working

surface with the foil side down. Then position the display board with the readouts face up and the bare leads facing the front of the main board (toward the line of holes). Slip the leads from the display board into their mating holes on the main board and bend the display board up so that it forms a 90-degree angle to the main board. The two should be just barely touching. Keeping the display board perpendicular to the main board, carefully solder all of the interconnecting leads. Connect the insulated jumper between IC1 pin 16 and IC3 pin 1. Use short lengths of insulated wire to connect S1 and S2 to their respective pads on the board. Connect longer lengths of insulated wire to the power, ground, and display control pads.

Select a small metal case that will accommodate the assembly with the digits close to the front. The two set switches should be installed on the rear of the case, with the three leads (power, ground, and display control) coming out through a grommetted hole on the rear. If desired, the front panel can be cut so that a red plastic window magnifier (similar to those used in calculators) can be used over the numerals. The magnifier can be cemented in place on the inside of the front cover.

Checkout and Calibration. Connect the power and ground leads to a source of 11 to 14 volts dc observing the correct polarity. The display will come on when the control lead is connected to the positive supply. Operat-

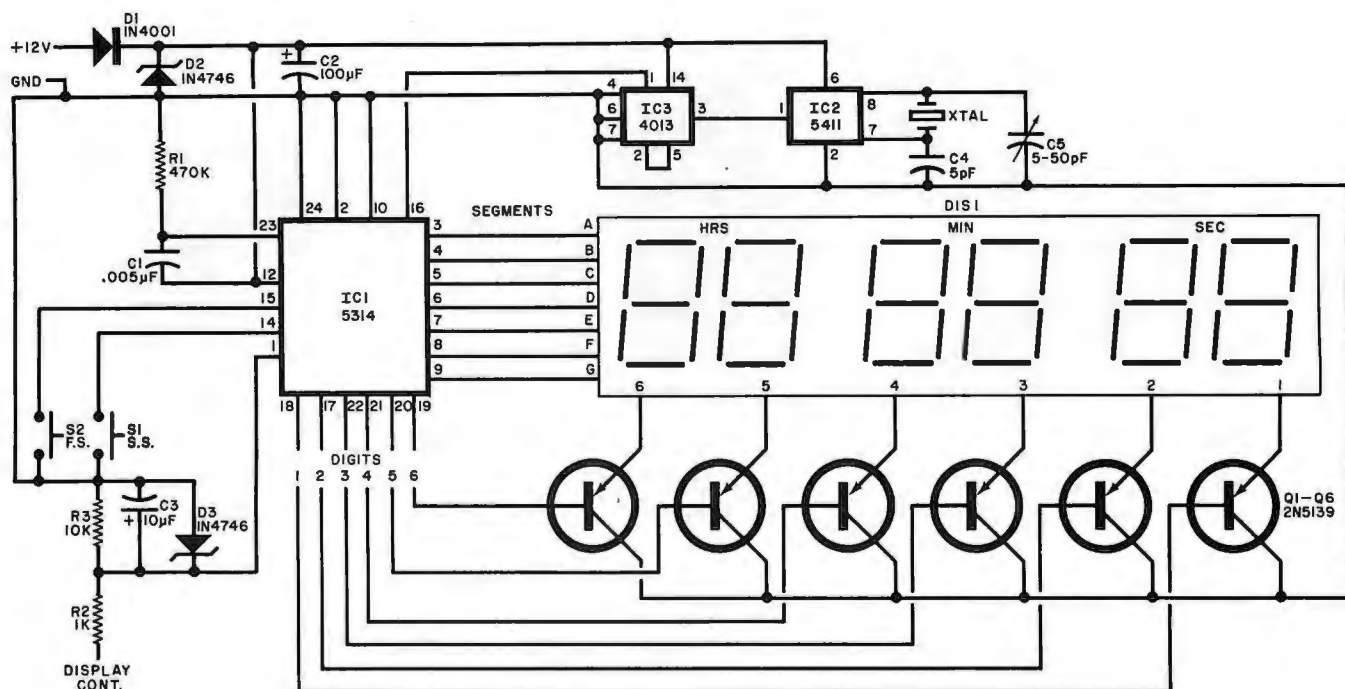


Fig. 1. Crystal oscillator is counted down by IC2 and IC3 to drive clock circuit in IC1.

PARTS LIST

C1—0.005-µF 16-V disc capacitor
C2—100-µF, 16-V electrolytic capacitor
C3—10-µF, 16-V electrolytic capacitor
C4—5-pF ceramic disc capacitor
C5—5-to-50-pF trimmer capacitor
D1—1N4001 diode
D2,D3—1N4746 zener diode
DIS1—9-digit, 7-segment board (only 6 digits used) See Note.
IC1—MM5314 clock module (National)
IC2—SCL5411 oscillator-16-stage binary

divider (Solid State Scientific)
IC3—4013 dual D flip-flop (only one used)
Q1 through Q6—2N5139 transistor
R1—470,000-ohm, ¼-W resistor
R2—1000-ohm, ¼-W resistor
R3—10,000-ohm, ¼-W resistor
S1,S2—Spst, normally open, pushbutton switch
XTAL—6.5536 MHz crystal
Misc.—Suitable enclosure, red plastic

magnifier, cement, double-sided tape, mounting hardware, etc.

Note: The following are available from Alpha Electronics (Texas), Box 64726, Dallas, TX 75206: complete kit of parts less case (AC-1) at \$29.95 plus \$2.50 postage and handling; crystal at \$7.50; aluminum case with cover and magnifier (C-1) at \$4.50; etched and drilled pc board (140576) at \$5.00; assembled display board (AE-9) at \$4.95.

ing the slow set switch, S7, should cause the seconds to "run" rapidly and the minutes to operate at a faster speed than normal. The fast set switch, S2, causes the seconds to stop and the minutes and hours to run rapidly. Operation of both switches can be used to set the time.

To adjust the accuracy, and if you have a frequency counter, connect the latter between IC2 pin 7 and ground. Then adjust trimmer capacity C5 for a reading of 6,553,600 Hz. If you don't have a frequency counter, adjust C5 periodically by trial and error. Even if C6 is off slightly, the clock should still keep better time than most standard automotive clocks.

Installation. The clock can be installed under the dash or in any other convenient location. Connect the ground wire to any ground point on the vehicle and the +12-volt line to any point that is fused and is "live" even when the ignition key is removed. Connect the display control lead to any +12-volt line that is live when the ignition key is inserted.

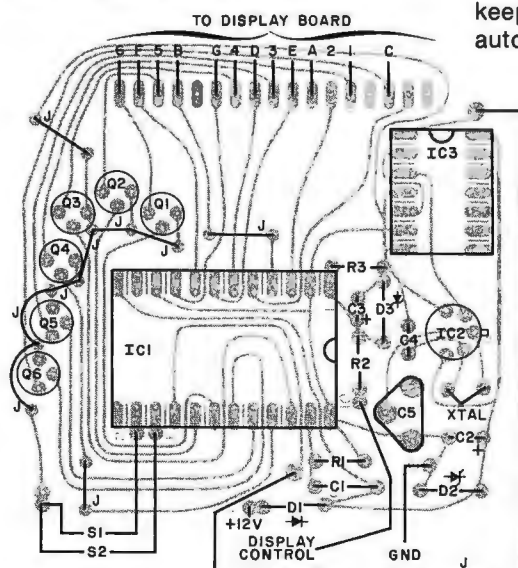
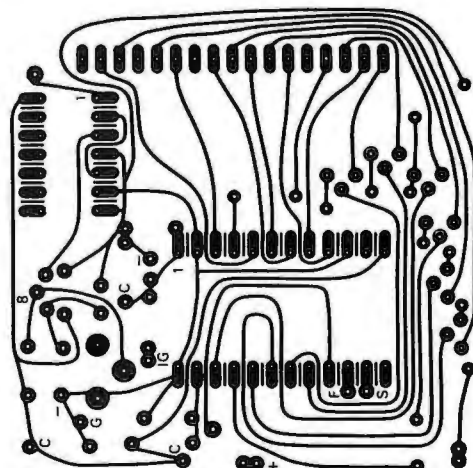


Fig. 2. Actual-size etching and drilling guide (right) and component layout (left) for digital clock. Holes at top of board align with those on the display board.



Build the "ROADMATE" CB CONVERTER



BY DEAN TODD

Compact converter allows you to listen to all 23 CB channels on any AM radio.

THE NEXT best thing to having a CB transceiver in your car is to be able to listen to any of the 23 CB channels through your car's AM radio. This way, you can keep up with the latest traffic information, know where the jams are and which roads are open and closed, etc. The low-cost "Roadmate" AM-to-CB converter discussed here lets you listen in for less than \$14 in parts.

The Roadmate connects directly between the existing antenna and car radio and only requires hookup to the car's electrical system to complete installation. You can leave the converter permanently connected because a switch allows selection of CB or AM listening.

How It Works. The schematic diagram of the converter is shown in Fig. 1. The converter, installed between the antenna and the radio's r-f input, serves as an added "front-end" for the radio. The antenna plugs into *J1*, while *P1*, located at the end of a length of coaxial cable (the same type used in car radio antenna installations), plugs directly into the antenna jack of the car radio.

When *S1* is set to CB, field-effect

transistor *Q1* is used as a mixer that accepts the incoming 27-MHz CB frequencies from antenna transformer *T1*. It mixes these signals with the 26-MHz third harmonic signal developed by the crystal-controlled *Q2* oscillator to produce an i-f of approximately 1 MHz. Since the car radio tunes from 550 to 1600 kHz, the output of the converter is roughly in the center of the AM broadcast band. This means that the car radio can be used as a "tunable i-f" so that the CB channels appear spotted along the AM band. Oscillator-to-mixer coupling is through *C4*, while r-f decoupling is provided by *L1*, *L2*, *C7*, and *C8*.

With *S1* in the CB mode, *LED1* is energized to give a visual indication of the type of operation.

Setting *S1* to RADIO switches *LED1* out of the circuit. It also completely bypasses the converter circuits and connects the antenna directly to the radio's input connector.

Construction. Best results will be obtained if the converter is assembled on a small printed circuit board, the actual-size etching and drilling guide and components-placement diagram for which are shown in Fig. 2.

Pushbutton switch *S1* and indicator *LED1* should be mounted so that they protrude through holes drilled in the front panel of the box in which the circuit is mounted. (The prototype project was housed in a 4¼" × 3¼" × 1¼"—10.8 × 8.3 × 3.2 cm—metal box.) Suitable mounting holes should also be drilled to allow the pc board to be mounted on spacers inside the box.

Mount antenna jack *J1* on the rear panel of the box, with the coaxial cable to which *P1* is connected exiting the box near the jack. Use red and black stranded hookup wire for the "hot" (+) and ground power leads, respectively. These wires should exit the box through a rubber-grommet-lined hole in the rear panel.

Use a pair of small L brackets or double-sided adhesive foam tape to mount the converter to the underside of the dashboard or wherever you feel it will be convenient to reach.

Installation and Operation. With the converter mounted as desired, connect the black power lead to any metal portion of the car's chassis and the hot (red) lead to any 12-volt line that is "live" when the ignition or car radio is turned on. Unplug the antenna

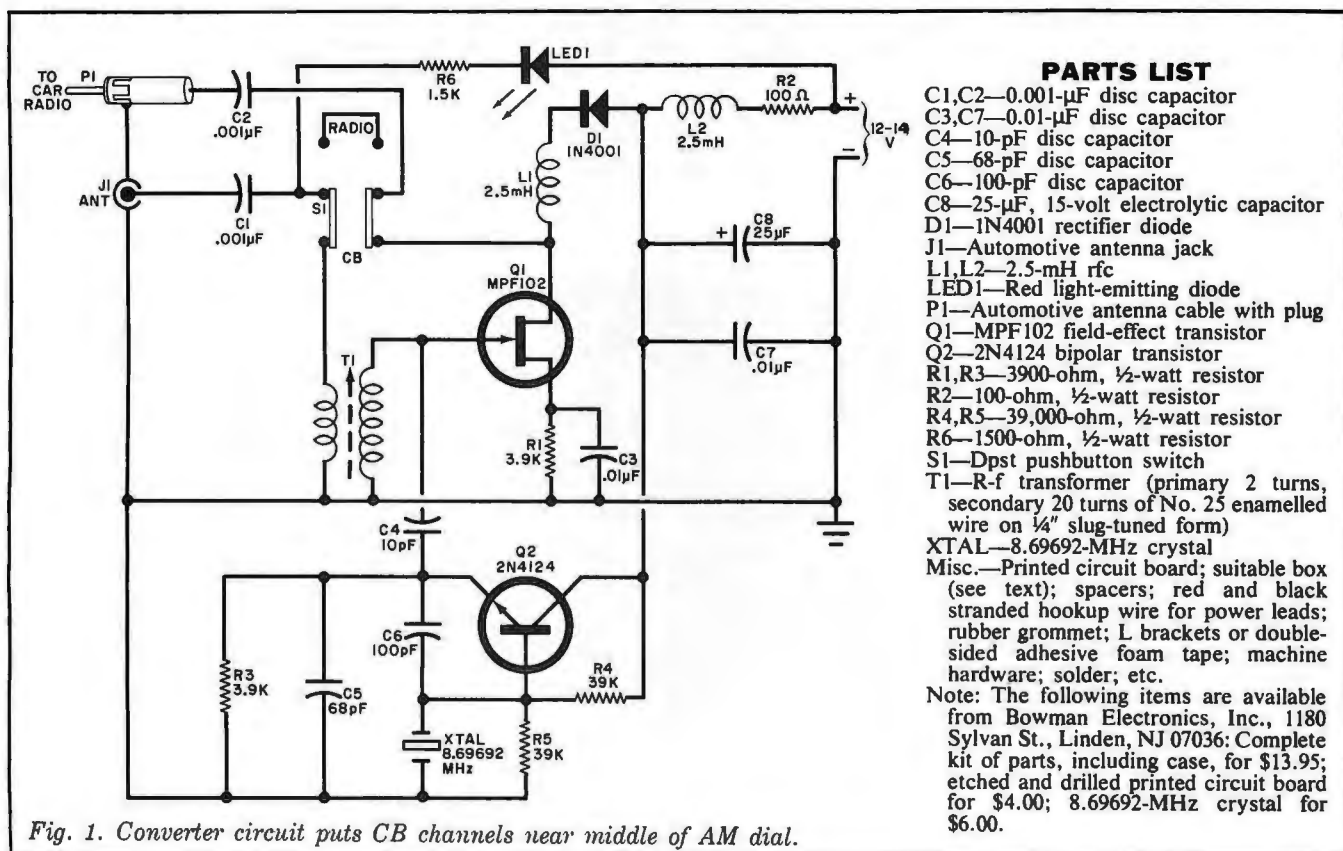


Fig. 1. Converter circuit puts CB channels near middle of AM dial.

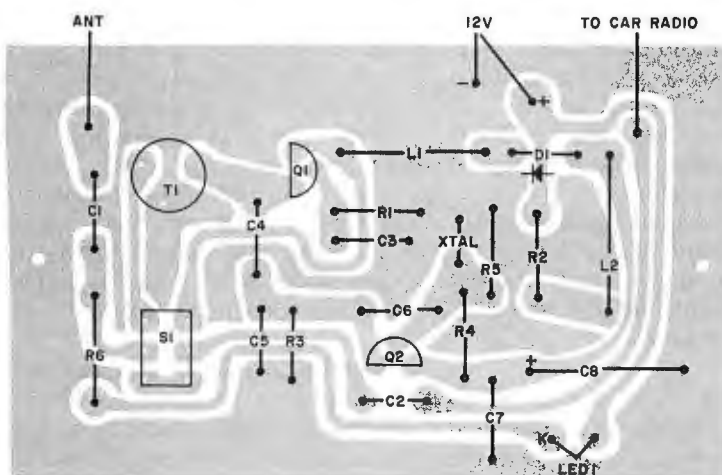
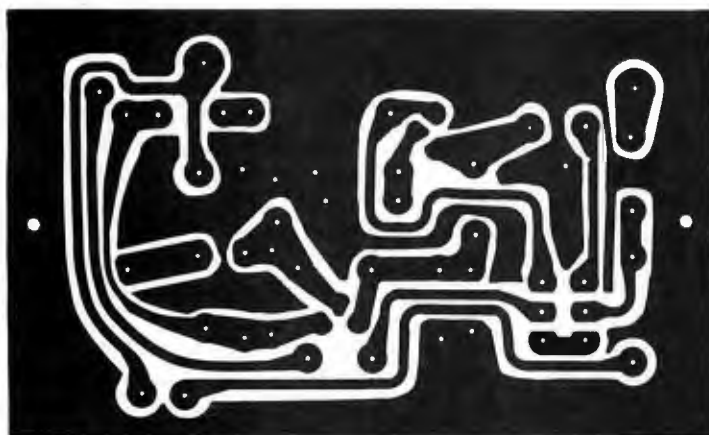


Fig. 2. Etching and drilling guide (top) and component placement for the converter.

from the car radio and plug it into J1 on the rear of the converter. Then plug P1 at the end of the converter's coaxial cable into the radio's antenna input jack.

Turn on the car's ignition (or radio) and depress S1. This sets the converter up for CB operation. The LED on the front panel should glow. Tune the car radio to about the center of the AM dial (approximately 1000 kHz) until you hear a CB transmission. As you continue tuning, you should be able to pick up all 23 CB channels. You can now "peak" T1 and the car radio's antenna trimmer capacitor for best reception.

Set S1 to its alternate (RADIO) position. The LED should extinguish and you should be able to tune standard AM broadcast stations as usual.

Options. By changing the crystal frequency, it will be possible for you to pick up other frequencies near the 27-MHz CB band, such as hams working 10 meters (28 MHz). By changing the windings of T1 and the crystal frequency, it is possible to tune in some of the popular shortwave bands, including WWV. Of course, you will have to experiment with the windings of T1, and you will have to select a crystal so that one of its harmonics falls within 1 MHz of the desired frequency. ♦

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What's New In Tape Recorders?

An overview of recent developments in tape decks and formats.

... Four. Three. Two. One ...

0.0005: Oscillator start-up.

0.008: Commence roll program.

0.100: Brakes off; pinch rollers on; motion start-up; head lock-in.

0.520: Motion stabilized; commence R & P programs.

0.590: Record current in line.

0.750: Play circuits in operation.

THAT isn't dialogue from a Cape Kennedy blockhouse of course, but an account of what happens inside a late model cassette deck in the first three quarters of a second after you go from stop to record. However, the resemblance to the programmed operations of Mission Control is both striking and intentional and is indicative of the sophistication in control and performance features found in many of today's recorders. To update you on such new developments, let's take a brief look at the cassette and open-reel scene.

Noise Reduction Systems. The slow tape speed and narrow track width of cassettes make some form of noise reduction necessary if hiss levels are to be kept competitive with phono discs and open-reel tapes. Six years ago, Dolby-B was about to be incorporated into a cassette recorder (the Advent 200) for the first time. Today, excepting inexpensive portables, it's hard to find a cassette that isn't equipped with this valuable system, in either discrete or IC form. To facilitate comparison with some of the newer alternatives to Dolby, a short review of

its operation is in order. The Dolby-B record characteristic, shown in Fig. 1A, affects *only* high-frequency, low-level signals, which are boosted (pre-emphasized) by carefully-controlled amounts before they reach the recording head. All other signals pass through the Dolby circuitry unchanged. The recording process will subsequently add some hiss, of course, but it is now below the level of the high frequencies which it might otherwise mask. On playback, the same frequency-sensitive network that was used for pre-emphasis now brings the highs back to their original levels (de-emphasis), as shown in Fig. 1B. Tape hiss is treated just like any other low-level, high-frequency signal, and is attenuated. An overall increase in signal-to-noise ratio (S/N) of about 10 dB is possible using this system.

The JVC "ARNS" noise-reduction system is sufficiently close in its operation to Dolby-B that tapes made on the one can successfully be decoded on the other. Recently, however, JVC has developed a second NR system called "Super ANRS" which treats the high-level, high-frequency signals

that Dolby and regular ANRS leave untouched. Within the upper portion (about -15 VU and above) of the dynamic range, the problem that cassettes face is not audible hiss, but high-frequency tape saturation. The large amount of record pre-emphasis that is an essential part of cassette recording can boost seemingly low-level program material, if high enough in frequency, to a level beyond what the tape can handle. The Super-ANRS circuitry detects these dangerously "hot" high frequencies and compresses them to a point that is acceptable to the tape before they are applied to the record head. On playback, these high frequencies are expanded back to their original level. This process, whose record and playback characteristics are shown in Figs. 2A and 2B, respectively, permits a somewhat higher overall recording level to be used than would otherwise be possible, resulting in an increase in S/N.

JVC is not the only company with an alternative to Dolby-B processing, however. dbx has recently announced that henceforth the Teac line will offer consumers a choice between incorporating Dolby or dbx noise-reduction

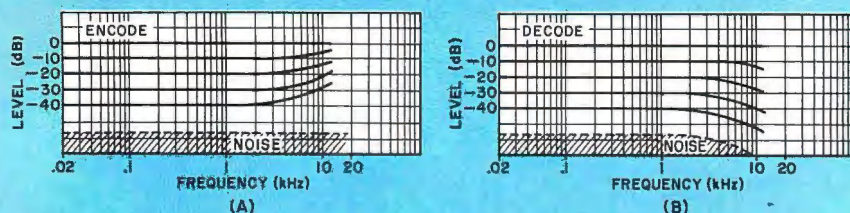


Fig. 1. Dolby-B noise reduction uses level-sensitive pre-emphasis on record (A) and complementary de-emphasis on playback (B).

circuitry. Unlike the systems previously discussed, the dbx technique, which has already generated considerable enthusiasm in the field of professional recording, does not restrict itself to portions of the frequency range and signal-level range. It's an all-out 2:1 compressor-expander (or *comparer*) which in theory could turn a cassette machine with a 45-dB signal-to-noise ratio into one with a 90-dB S/N! Because a certain amount of this tremendous increase will be used to provide additional headroom, the company's claims are slightly more modest—an effective noise reduction of 30 dB, as compared to Dolby-B's 10 dB. (Dolby cannot, however, decode Dolby-B cassettes, or vice versa.) Furthermore, because it has so much dynamic range to spare, the dbx system has no need of level-calibration tones and matching, which can make the Dolby system difficult to use. (If you use a tape with higher or lower overall sensitivity than that which was used to calibrate a Dolby system, frequency response will be altered when the tape is decoded.) To date, dbx noise-reduction has been available only as an add-on accessory; but now that Teac has taken the plunge, it is probable that other manufacturers will follow suit.

All three systems we have examined require flat frequency response, because roughly speaking, any frequency response errors between the encoding and decoding process will

be multiplied by the amount of compression used. For example, assume you are using the dbx system. (Dolby or ANRS would be similar, but not as drastic.) Your overall record/playback is down 3 dB at 10,000 Hz and you're recording a tone at this frequency whose true level is -30 VU. The noise-reduction circuitry compresses it by 2:1, and so records the tone on the tape at -15 VU. The tape, in this example, however, loses 3 dB at this frequency, so that, when the tone comes back for decoding, it does not arrive at -15 VU, but at -18 VU, instead. The decoder doesn't know about the error, however, and applies its 2:1 expansion factor, so the tone is now reproduced at a -36 VU level, representing a 6-dB loss in level.

The attempt to achieve wide, flat frequency response from the cassette medium goes beyond the specific needs of noise-reduction systems, of course, and today's cassette recorders are responding to the challenge in two basic ways: more bias and equalization combinations to meet the requirements of improved tapes; and improved heads.

The New Tapes. For years, every "quality" cassette recorder has carried a two-position switch to change bias, equalization, and (usually) meter calibration for ferric oxide and chromium dioxide cassettes. Indeed, there has even been considerable success in getting hardware and

software manufacturers to use a small slot in the rear of the cassette housing for a sensing arm that would make this switching automatic. But this presupposed that there was one basic ferric bias and equalization machine setting (as there is for CrO₂), which, up to and including development of TDK SD tape, was essentially true. With the exception of 3M's "Classic" cassettes, it remains true for American and European tapes, which are manufactured to use "DIN" or "standard" bias. (There are, of course, frequency response differences among these tapes, but no one has proposed adding switch positions to equalize these). However, to achieve a high-frequency response as good as (or slightly better than) chromium dioxide, tape formulations from Japan have been introduced (Fuji FX, Maxell UD and UD-XL, TDK Audua, Nakamichi EX and EX-II, etc.) which require more bias current and (depending somewhat on the machine) slight equalization changes as well. This would mean a three-position switch—HIGH, STANDARD, and CrO₂—or at least a choice (often unstated in owner's manuals) as to which "ferric" bias was being used. Then, to add to the confusion, came the "ferri-chrome" tapes (Sony FeCr and 3M Classic), consisting of a very thin layer of chromium dioxide on top of a thicker coating of ferric oxide, which require still another equalization characteristic (or, sometimes, a bit of juggling between bias and equalization switch settings.)

To round out the picture, the most recent crop of ferric tapes (TDK SA, Nakamichi SX, and Maxell UD XL-II) are designed to work with the chromium dioxide settings, taking advantage of the additional signal-to-noise ratio that they afford. All this represents progress, of course, but it adds an element of cost and potential consumer confusion if decks are to keep response as flat as possible with more and more tape innovations.

Heads and Transports. As long as cassette machines weren't expected to have a frequency response beyond about 12 kHz, a combination record/playback head with a gap width of about 2 microns (78 millionths of an inch) was considered an acceptable compromise. But many of today's decks go well beyond this, which means using a head with a narrower gap, such as 1.5 microns (60 mi-

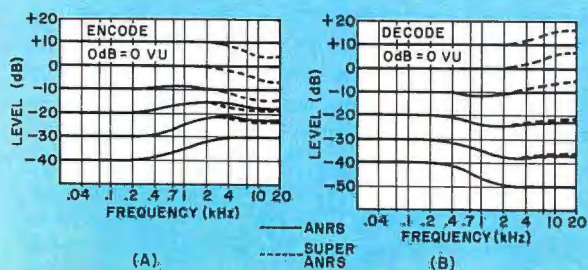


Fig. 2. Record (A) and playback (B) characteristics for JVC's new Super ANRS. It has high-level treble compression to avoid tape saturation.

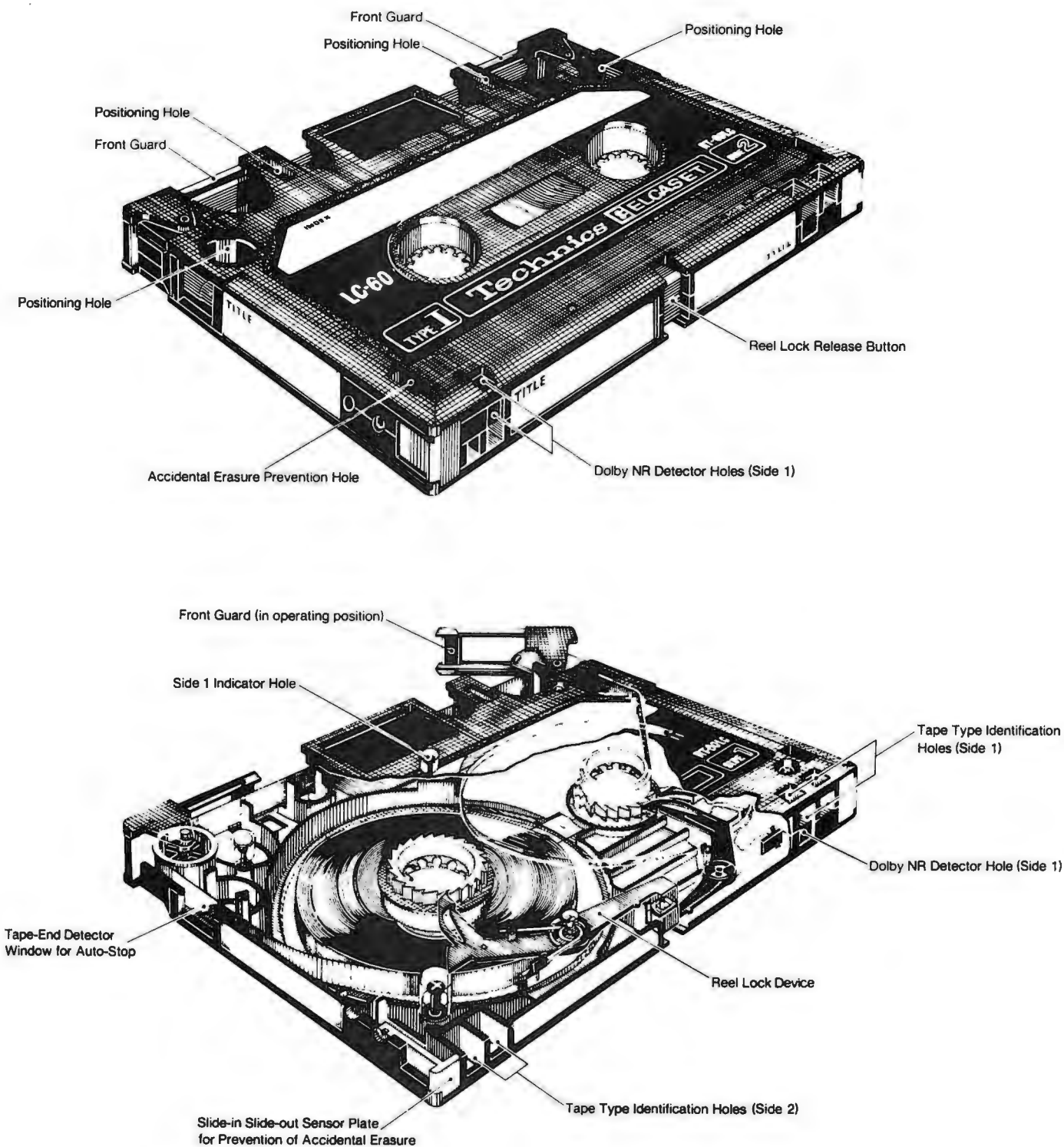


Fig. 3. Structural features of the new Elcaset. Format includes provisions for automatic switching of bias, etc.

croinches). Unless a special head design (for example, the "focused gap" Nakamichi technique) is employed, there is no way the head is going to be able to penetrate the full depth (about 5 microns) of the oxide coating on the tape during the record cycle.

The inability to "monitor off the tape," which requires separate record and playback head gaps, represented the final point of resistance in accept-

ing the cassette as a full-fledged high-fidelity recorder. The Nakamichi 1000 (and 700), with a separate record (5-micron gap) and playback (0.7-micron gap) heads, and an alignment system to optimize adjustments for each cassette (frequency response on many premium cassettes goes beyond 20 kHz), settled anybody's lingering doubts, but at a price very few audiophiles could even consider.

In today's market there are several "three-head" cassette machines to consider (Technics, Fisher, Sony, and Hitachi), and this is clearly the direction more manufacturers will take. The Hitachi is particularly interesting in this connection, for its 1.2-micron playback head and 4-micron record head actually share the same shell, reducing the need for "fine tuning" the record azimuth (a la Nakamichi) for

each cassette. As to whether heads should be made of ferrite or permalloy, each partisan's choice is much clearer than his argument. If wear is the principle concern, the nod goes to ferrite; but for very narrow gap application or very high record currents, permalloy appears to have the edge.

The transport mechanisms of many of today's cassette decks have taken full advantage of developments in semiconductor control circuitry. Servo-control capstan drives, which are now common, have contributed to the lowering of wow and flutter figures generally. Another important step in this direction is the dual-capstan drive, which isolates the length of tape actually crossing the heads from any eccentricities in the supply and take-up spools. Two-motor transports have further simplified the drive mechanisms and provided greater reliability. Logic circuits operating solenoids have made possible such features as automatic rewind and even selectable "memory rewind," in which the cassette will return to a specified point and "play it again, Sam." If the automatic reversing feature is of interest to you, you'll find it in decks by Akai and Dual.

Cassettes began their meteoric rise to popularity simply as battery-operated dictating devices; but after acquiring "hi-fi" status, scant attention to truly portable operation was paid. Happily, among today's models, that oversight has been corrected. If you need a quality machine capable of being battery powered, you can choose models from Sony, Nakamichi, JVC, Uher, and Yamaha.

New Cassette Sizes. The only troublesome cloud on the horizon for today's cassettes is the fact that the once standardized cassette package is now being threatened by two new cassette sizes. On the one hand, Philips (originators of the standard cassette format) has been experimenting with another portable dictating device, which is even smaller and operates at slower speed than the "cassette." In all likelihood, this mini-cassette package will remain confined to voice recording applications, though one never knows!

Of greater immediate threat to the standard 1 $\frac{7}{8}$ -ips cassette as we know it is a recent announcement made by three tape deck manufacturers—Sony, Technics by Panasonic and Teac. The three have reached an

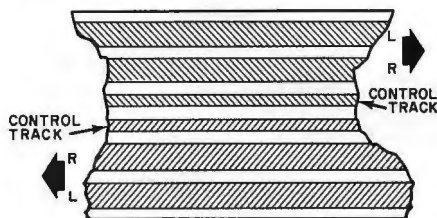


Fig. 4. Elcaset has four audio and two control tracks on quarter-inch wide tape.

agreement on the "standardization" of a tape package which they call the Elcaset. The Elcaset system realizes both the convenience of the more compact cassette (the new Elcaset package is approximately as large as an 8-track cartridge), but from all preliminary indications will be able to offer further improvements in sound quality and consistency of tape motion.

For example, the Elcaset will house quarter-inch tape, the same width used in open-reel machines. This, combined with a tape speed of 3 $\frac{3}{4}$ ips, should provide much wider dynamic range (or improved S/N) than is possible with regular cassettes. In addition, the tape itself is pulled out of the Elcaset shell for transport across the tape heads, so that precision of shell construction (or lack of it) will have little effect on the running of the tape.

A diagram of the new Elcaset's construction is shown in Fig. 3. Note that several "detection holes" for a variety of automated features are built right into the cassette shell. These extra holes can provide for automatic selection of proper bias and equalization to match at least three types of tape. A notch will also detect whether or not noise reduction circuitry is to be switched on for playback of a given Elcaset, which side is being played, etc.

Compatibility between mono and stereo tapes will be retained (just as it is in standard cassettes) and the track pattern, at least as far as audio tracks are concerned, will be the same as that of standard cassettes, as illustrated in Fig. 4. Note, however, that there are two additional narrow tracks running along the center of the tape. These are intended as control tracks—one for each direction of tape travel—which could be used to record synchronizing pulses (for film or slide presentations, etc.) and may also serve for other control purposes not yet imagined.

Sony has already produced at least two tape decks designed for use with the new Elcaset package and others

are sure to follow. The three sponsors of the new package indicate that Aiwa and the Victor Company of Japan, Ltd (JVC) have also agreed to adopt the new Elcaset format in products they will manufacture for consumer use. It is difficult to predict what impact the Elcaset will have on the presently expanding standard cassette market; but certainly with many important companies behind the new project, the Elcaset bears watching in the future. At the very least, its potential for better fidelity is sure to appeal to the really demanding audiophile, who, until now, would settle for nothing less than a high-quality, open-reel tape deck.

Open-reel Tape Decks. These machines have always enjoyed their greatest popularity among serious recordists, whose frustrated desire all along has been to own the genuine studio article. They accepted the quarter-track format only with reservations. After all, the pro's gain 3 dB in S/N by using half-track, and if you expect to be doing a certain amount of editing, there's not even a tape saving. How about 3 $\frac{3}{4}$ ips? Suitable for background music perhaps, but surely not for anything serious! The very inconvenience of tape threading is turned into a ritual to be performed with practiced ease to conjure up the closest approximation to the live performance. And now that cassettes have all but completely driven the low and middle priced open-reel machines from the market (there seem to be more decks for over \$1000 than for under \$500, though most are in between), the open-reel enthusiast can survey the current offerings with the satisfaction of having been right all along. The studio goodies, right down to multi-tracking, are simply pouring forth.

For starters, 10 $\frac{1}{2}$ " reels and a 15-7 $\frac{1}{2}$ ips option are in almost everyone's line, and anything less than three heads and three motors has virtually disappeared. The higher tape tensions, rotational forces encountered, and greater demands on the braking systems that go with the big reels have had the salutary effect of forcing recorder manufacturers to pay more attention to the design of their transport mechanisms. In addition to heavier motors, one result has been the widespread introduction of "logic-controlled" decks, whose solid-state circuits sense tape motion and speed,

and prevent the accidental execution of commands (e.g. to go directly from rewind into play without first coming to a full stop) that would fill the room with flying tape bits. And once logic-actuated solenoids are in place, full remote control, automatic reversing (Akai, Sony, Teac), and memory rewind (Teac and Revox) are relatively easy to provide.

Quite a number of open-reel manufacturers turned to dual-capstan, "closed-loop" drives (Akai, Revox, Sony, Teac) to insulate the tape from any shocks that might be transmitted from the supply reel. The Sony TC-880 and Revox A700 take advantage of this to provide a counter that reads directly in minutes and seconds rather than in arbitrary revolutions. The Revox goes even a step further by providing a sensing device that servo-controls the supply and take-up reel tensions even when reel sizes are intermixed. The Sony, for its part, boasts what is surely the most advanced metering system made available to the home recordist: a 55-dB range, light-actuated meter whose characteristics can be set either for VU, for peak-reading, or to hold the highest peak encountered. Again, to control tape speed both instantaneously (i.e. to ensure against

wow and flutter) and over a period of time (for variable pitch, for example), a number of machines have gone to servo-controlled capstan motors. Several, too, utilize plug-in head block assemblies, so one can select between half-track and quarter-track formats, and many provide front-panel bias adjustment (by switching, continuous control).

While 4-channel sound in general has not taken the country by storm, response to 4-channel recorders with a multi-sync capability (Akai, Crown, Dokorder, Otari, Teac) has been extremely strong, underlining the desire of many recordists to copy the studio technique of multi-tracking, or "over-dubbing." If this sounds strange to you, consider that in producing a typical pop hit, 8, 16, 24, or even 32 individual sound tracks will be recorded—often over a period of days or even weeks—all of which must ultimately be combined ("mixed down") into conventional stereo. Each track must nonetheless be recorded in perfect synchronization, or the mix-down becomes an impossibility. To achieve this, each successive performer listens (via headphones) to a playback of what has been previously recorded. But this playback must *not* come from

the normal playback head, or his own efforts would be displaced by the amount of time it takes the tape to move from the record to the playback head. Instead, a "multi-sync" switch (known by various trade names) is thrown to temporarily convert part of the record head (where a track has already been laid down) into a playback head. The fidelity of this kind of playback isn't as good as the regular playback head will later provide, but it keeps everything together.

A home 4-channel recorder doesn't have the full flexibility of the studio machine, of course, but surprising things can be done. If tracks 1, 2, and 3 are recorded individually, they can then be combined (adding still a fourth live part, if desired) onto track 4. If the mix is satisfactory, tracks 1, 2, and 3 can be erased and re-used, after the same fashion. This tends to meet the needs of most groups, allowing them to work out their arrangements so fully that if they have to go into a studio at all, they will require minimum studio time. Given what studios charge today, the savings can pay for a 4-channel machine rather quickly. But maybe even more important in the long run, is the fact that it's *fun* to be your own engineer! ♦



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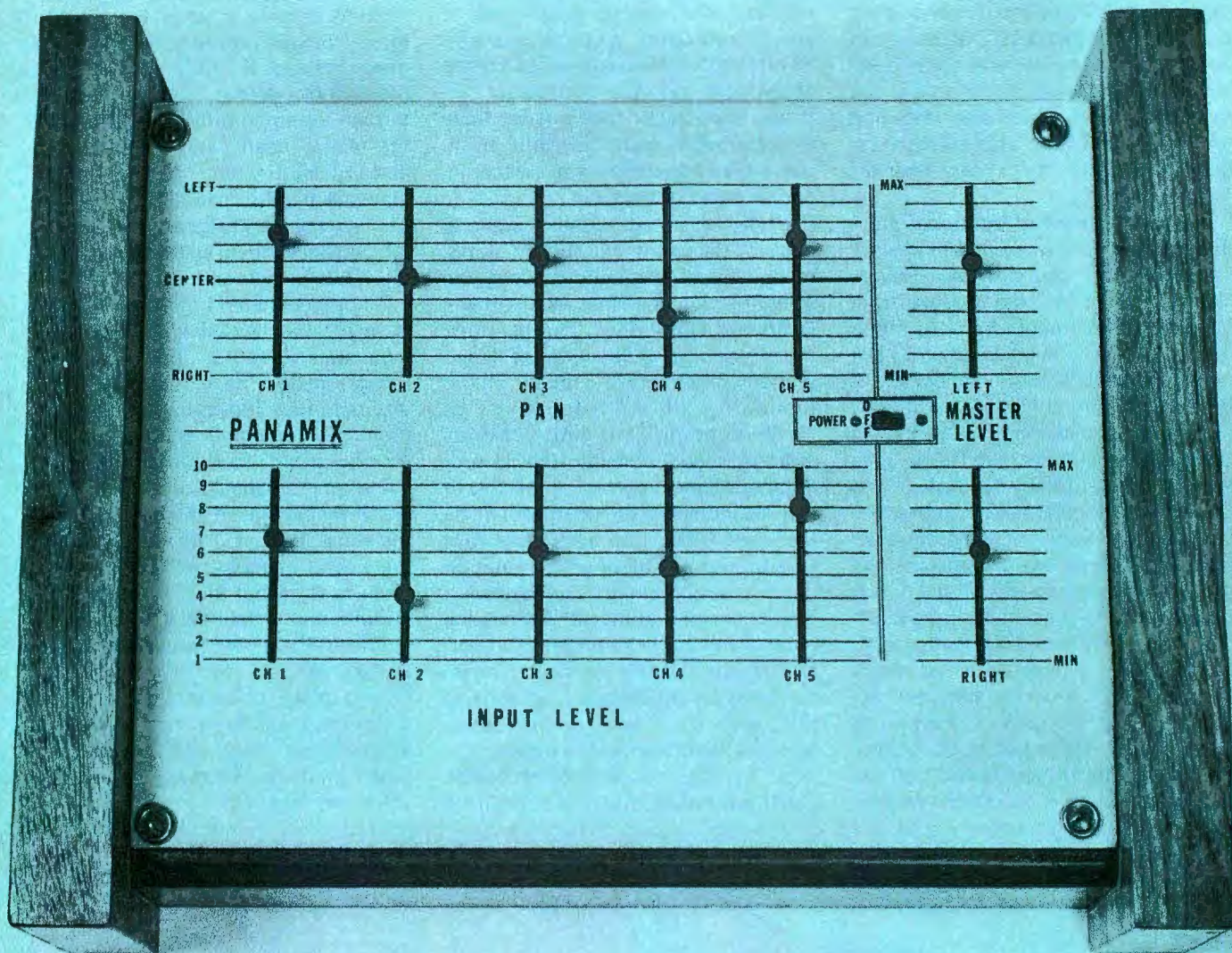
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Build PANAMIX

*A low-cost, 5-input
stereo/mono audio mixer
with full panning*

BY JAMES BARBARELLO

PANAMIX is a stereo/mono mixer that can handle up to five inputs at once, and has full panning capability. Unlike many other mixers, it will allow you to position each program source at full left, full right, or anywhere in between.

All controls, including input and master level controls, are slide potentiometers, giving the project the look and "feel" of a studio-type mixing panel. Panamix also uses readily available components, such as 741-type op amps. Current drain is so low that 9-volt transistor batteries are a practical and economical power source. Total parts cost is only about \$30.

About the Circuit. Referring to the schematic diagram (Fig. 1), three distinct sections can be identified. The first is the input level control section

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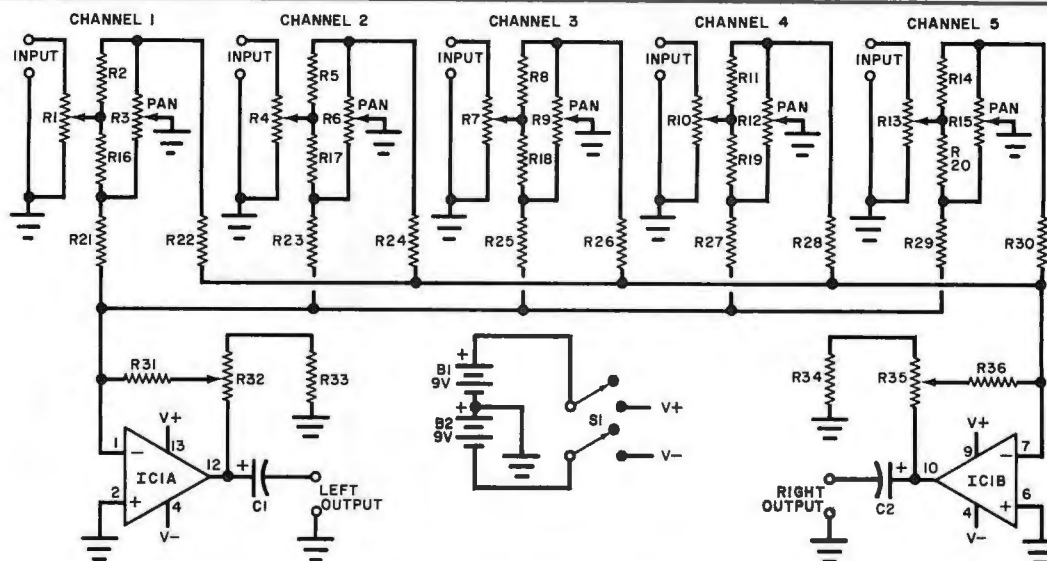


Fig. 1. Schematic diagram shows how five input channels are mixed down to a stereo output by an op amp summer.

PARTS LIST

B1, B2—9-volt transistor battery
C1, C2—1- μ F, 16-volt electrolytic capacitor
IC1—747 dual operational amplifier
R1, R3, R4, R6, R7, R9, R10, R12, R13,

R15, R32, R35—10,000-ohm slide potentiometer (Radio Shack 271-223)
R2, R5, R8, R11, R14, R16 through 31, R36—10,000-ohm, 5%, 1/4-watt resistor
R33, R34—1000-ohm, 5%, 1/4-watt resistor
S1—DPDT toggle switch

Misc.—Battery clips; 10" \times 7" printed circuit board; 7 miniature phone, RCA phone, or 1/4-inch phono jacks; hookup wire; solder; wood and sheet metal screws; etc.

(R1 for Channel 1), a 10,000-ohm potentiometer. It presents a constant resistive input impedance of 10,000 ohms and provides a variable amplitude signal to the second section, the panning circuit. For the input Channel 1, it consists of R2, R16, and potentiometer R3. As the wiper of R3 is moved upward, less and less signal appears at the right output, while more and more appears at the left output. If the wiper is then moved downward, the apparent position of the signal source moves from left to right. Although the position of the panning control does affect the total output of the panning section, the variation is not audibly noticeable.

The left and right outputs of the panning section are then processed by the third section, which performs output summing and level control functions. For the left channel output, it is composed of R21, R23, R25, R27, R29, R31, R32, R33, C1 and IC1A. These components form an op amp summer whose gain, allowing for losses in the panning section, is about 15 dB over the input signal level. The output impedance of each section of IC1, a 747 dual op amp, is about 75 ohms. Thus it will drive almost any

preamp or power amp with a medium to high input impedance. Each output is capacitively coupled to dc-isolate the output stage of the op amp from the output jacks.

Construction. "Panamix" is best assembled using a 10" \times 7" (25.4 \times 17.8 cm) printed circuit board. Figure 2 shows the etching and drilling and parts placement guides. Start by inserting all fixed resistors and soldering them into place. Then insert and solder IC1, using an IC socket or Molex Soldercons, if desired.

The slide pots have three terminals (one at one end and two at the other) and two tabs near the center. Insert each potentiometer carefully, so that the two tabs are touching the circuit board and the body of the potentiometer is perpendicular to the pc board. When you have correctly positioned each potentiometer, solder it in place. Then install C1, C2, R33 and R34 on the foil side of the board. This is done so that the board can be mounted in a custom enclosure. Attach leads for the input and output jacks and for S1, also using the foil side of the board. These leads are connected to the foil side to prevent any interference with the mo-

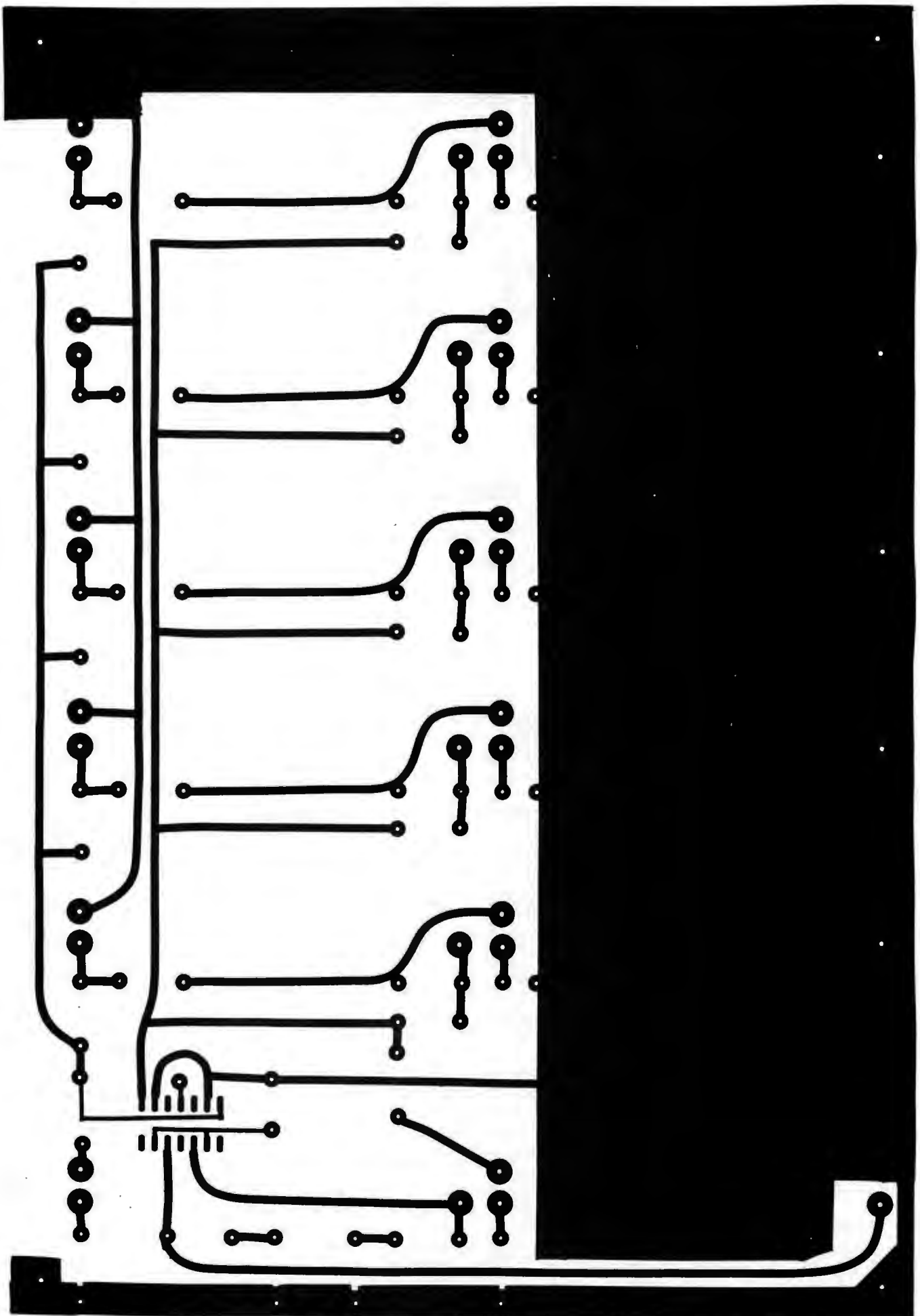
tion of the slide pots. All input and output leads should be shielded. The choice of connectors is optional. The author used miniature phone jacks for input and output connections, but RCA phono or standard 1/4-inch phone jacks can also be used.

Because the circuit draws only \pm 4mA, two nine-volt transistor batteries are used for a power source. You can power the Panamix from a line-operated supply, of course.

With all parts and connectors in place, Panamix is electrically complete. However, you will probably want to build an enclosure for the mixer. So a custom cabinet plan is included.

Layout of the front panel, which is formed from an 11" \times 8 1/2" \times 1/8" (27.9 \times 21.6 \times 0.32 cm) piece of Masonite is shown in the photo. Twelve 2 1/4" \times 1/8" (57 \times 3.2 mm) cutouts should be made to accommodate the control slides. A 1/4-inch (6.4-mm) hole is for power switch S1. Assembly details for the case are shown in Fig. 3. Hardwood is suggested for all sections except the circuit-board supports, which should be pine. White glue and 1/4-inch (6.4-mm) dowels can be used for mechanical rigidity and a pleasing appearance.

When the case and front panel have



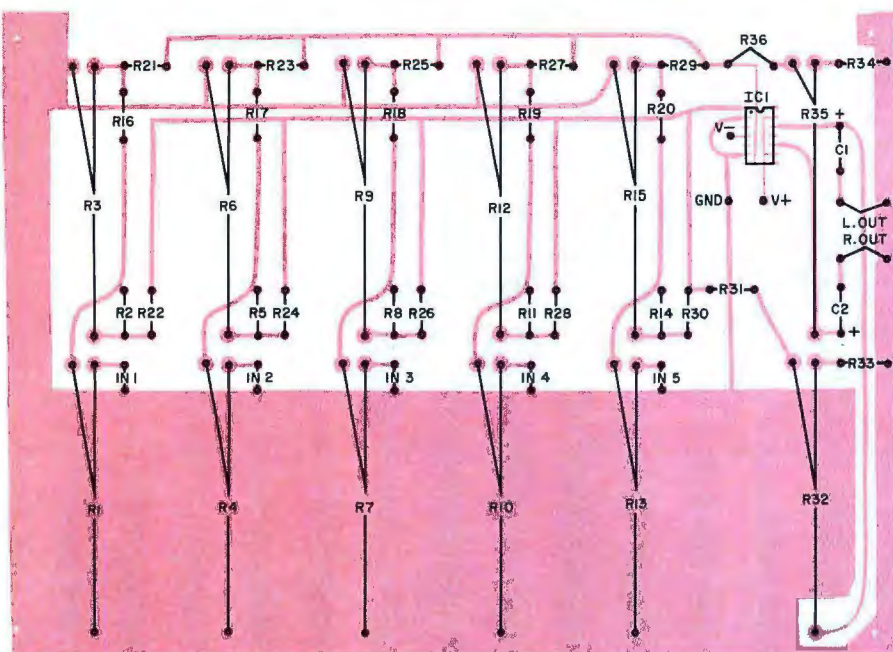


Fig. 2. The actual size etching and drilling guide for the printed circuit board is shown on the opposite page. Layout of components on the board is above.

been assembled, mount the panel and secure it to the support, with wood screws. Then turn the case upside down, and insert S1 into its mounting hole. Position the printed circuit board so that the slide controls move freely in their front panel slots. It might be necessary to bend the controls' solder lugs slightly to obtain smooth

motion, but be careful not to damage the pots, the board, or its foil. When the board has been properly aligned, it should be secured to the pine supports with self-tapping sheet metal screws. Press knobs down on each slide control.

A rear panel should be fabricated from a 12" x 1 1/2" (30.5 x 3.8 cm) piece of 16-gauge aluminum stock. Bend

the piece of aluminum at right angles 1/2" (1.27 cm) from each end to form a stubby "U" shape. Then attach the panel to the case, sinking sheet metal or wood screws through both arms of the "U". Drill mounting holes for the connectors you wish to use along the rear panel, and secure the jacks to the panel. Situate the batteries in any convenient location that will allow easy replacement. A retaining bracket for the batteries can be fashioned from a scrap of aluminum stock and should be secured to the case with a sheet metal or wood screw.

Using the Mixer. You can perform many different mixing functions with Panamix, such as converting a four channel "master" of a musical performance into a stereo format, mixing a multiple microphone conference setup into one or two tracks for recording or PA purposes, etc. You need only remember that panning position integrity with respect to the front panel markings is maintained *only* when both master level controls are set for equal volume. A significant difference between the levels of the output channels will shift the apparent "center" to one side. Experiment with all controls to get used to their "feel." For mono use, place all PAN controls to one side and use the appropriate output channel. ♦

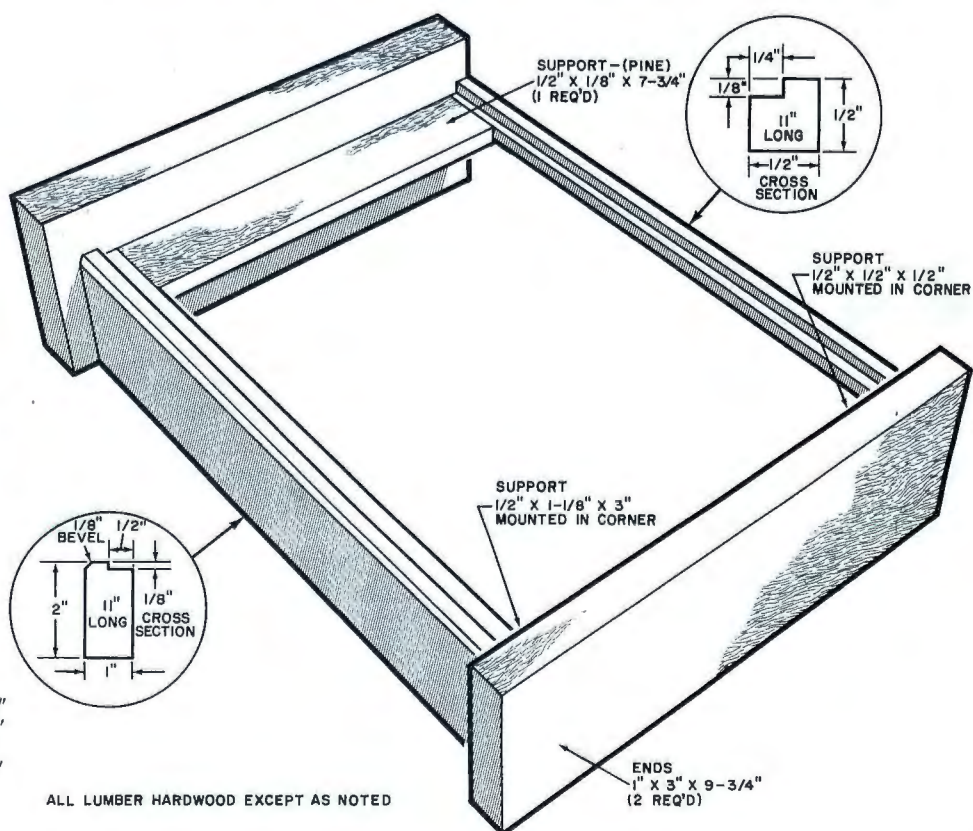


Fig. 3. A custom case for the Panamix can be made using this guide.

Bill of Materials

- 1—piece of Masonite 11" x 8 1/2" x 1/8"
- 2—pieces of hardwood 9 3/4" x 3" x 1"
- 1—piece of hardwood 11" x 2" x 1"
- 1—piece of hardwood 11" x 1/2" x 1/2"
- 1—pine support 7 3/4" x 1 1/8" x 1/2"
- 1—pine support 3" x 1 1/8" x 1/2"
- 1—pine support 1/2" x 1/2" x 1/2"

ALL LUMBER HARDWOOD EXCEPT AS NOTED

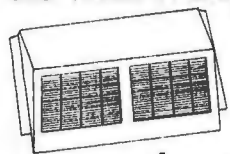
FOR THE BEST CAR SPEAKERS AROUND THIS IS WHAT YOU SHOULD LOOK FOR.



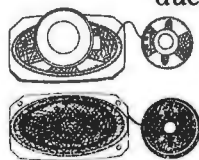
AND THIS IS WHY.

For the past eight years we've had more speakers on the road than anyone else. So even though you may not have heard of the Sparkomatic name, you've probably been listening to the Sparkomatic sound.

Our SK-250 stereo speaker set undoubtedly helped make us number one. When we first engineered this



"dual" speaker concept eight years ago, it was the only car speaker that could pro-



duce anything close to the high fidelity sound of home speakers.

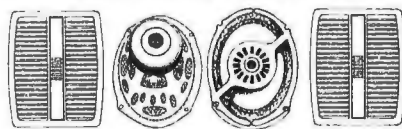
Since then everyone's been trying to imitate us.



After breaking that sound barrier for the car, we soon went even further and engineered our coaxial speakers.

We mounted the woofer and the tweeter on the same axis (to deliver more natural bass and treble reproduction) and connected a capacitor crossover network to allow each speaker to operate at its peak level. Now our coaxial stereo

speaker line-up includes the SK-620C which is a trim in-door model, the SK-520C, an easy-to-



install hang-on and the SK-6920C, a rear deck mount designed to fit most existing rear deck cut-outs. All have twenty ounce magnets, well worth their weight to produce the best there is in car sound.

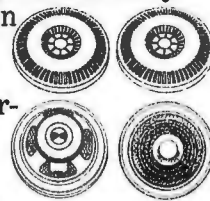
Our SK-355 stereo set is another example of Sparkomatic engineering know-how. We kept it small in size so it would be very much at home in compacts and mini imports. It has respectable five ounce magnets and air suspension cones so you can have big sound in small places. The SK-303 "tach" style speaker is also designed for small car application with the ease of hang-on installation.

No matter what size or price our speakers are, we put the same Sparkomatic expertise into everyone of them.

Like our SK-510 stereo speaker set. Moderately priced, yet, with

hard working ten ounce magnets and excellent range and delivery.

It's an easy hang-on installation. Or, if you're looking for the same characteristics in an in-door application, our SK-610 is the one.



If you're still into monaural sound we have a wide range of individual high fidelity speakers. (We're perhaps the only company that does.) These rear deck speaker kits come complete with a dash mounted switch for adjusting the sound from front to rear or for a combination of both. They're available in two sizes, 6 x 9 and 5 x 7, and they fit the existing cutouts in the rear decks of most cars.



We make all of our speakers easy to install—most people do it themselves. All are quality engineered for every kind of car radio and tape deck there is. With Sparkomatic speakers you can fill your car with a world of sound that is comparable to what you hear at home. And now you know why Sparkomatic makes the best car speakers around.

SPARKOMATIC

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TOOLS FOR ELECTRONICS EXPERIMENTERS



*Today's components and circuit designs
require some special tools and techniques.*

BY A. A. MANGIERI

TODAY'S hobbyist/experimenter must cope with many problems that never existed before the advent of printed-circuit technology, integrated circuits, and other microminiature devices. In the old days, you could get along with a set of screwdrivers, longnose pliers, diagonal cutters, and a soldering iron or gun. Now, without the aid of suitable tools, and technical aids, you will find it difficult—if not impossible—to build a complex IC project.

Printed circuit boards alone have created a number of problems. Special tools are required to cut the boards to size, drill numerous tiny

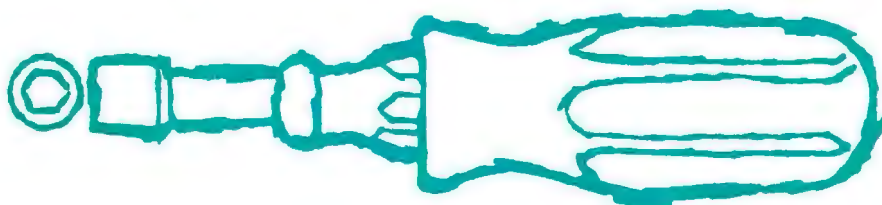
holes with bits that can't practically be chucked into a massive electric hand drill, and solder components without lifting the copper or scorching the board material.

Even solid-state devices place demands on tools that the old tool lineup can't begin to meet. Heat-sensitive, and now even static-electricity-sensitive, transistors and integrated circuits can be permanently damaged by old-fashioned tools. Obviously, then, you need special tools to work with modern electric devices and techniques. Some of these tools are highly specialized; but if you do a lot of experimenting, they'll pay for them-

selves. Other tools can be used for a broad range of jobs. The main point is that if you need a special tool for a given job, you can't make do as you could in the past.

First, let's review some of the basic tools every hobbyist/experimenter must have. Then we'll describe a few tools that aren't essential but will be great time savers when you do a lot of experimenting. Finally, we'll discuss how to judge tool quality to make your investment pay for itself in long tool life.

Pliers and Cutters. At the very minimum, you will need longnose



pliers, wire cutters, and slip-joint pliers. These three plier-type tools will see the most service in assembling kits and projects. Start with standard-size longnose pliers and diagonal cutters. Then, if you anticipate doing a lot of work with miniature components, you can add miniature longnose pliers and diagonal cutters. As your budget allows, you might consider adding tip-cutting, end-nipping, and round-nose and flatnose pliers. Each tool you add can be used for special types of jobs, and most are interchangeable.

One type of plier tool that most people in electronics often overlook is the plier-wrench, commonly called "vise-grips." Not only is this tool excellent for applying brute torque for turning bolts and nuts, it also can serve as a "third hand" for holding small parts, printed circuit assemblies, and small circuit assemblies. For a light grip, you close the jaws on the work by turning the adjusting screw. Used with C clamps



to serve as legs, the vise-grip plier will allow you to elevate and position the work as required.

Pliers should *never* be used on nuts and hex or square-head screws. At least that was the rule before Brookstone Co. came out with a plier specially designed for nuts. Resembling standard linesmen's pliers, this tool has two large sets of notches in its jaws that afford a slip-proof grip on nuts and screws.

The Brookstone, Jensen Tools and Alloys, etc., catalogs list several different kinds of plier tools of various



grades and functions. There are carbide-edged cutters, round- and box-nosed pliers, pliers with brass inserts in their jaws for mar-proof work,

and even pliers made from surgical steel. Needless to say, you don't need all—or even a majority—of the pliers and cutters mentioned, but if you add a few of the special items to your tool lineup, you'll find your project and kit building a great deal easier.



Drivers and Wrenches. A minimum list of screwdrivers should include $\frac{1}{8}$ " (small with pocket clip), $\frac{3}{16}$ ", and $\frac{1}{4}$ " slot-type and No. 1 and No. 2 Phillips-type drivers. Although you won't have as frequent a call for them as for standard-size drivers, a set of jeweler's screwdrivers is generally inexpensive enough to include in your basic list. Many shaft coupler and control-knob setscrews and the hardware on variable capacitors, etc., are so tiny that only a jeweler's screwdriver is safe to use with them.

Much of the machine hardware in commercial electronic equipment and the setscrews in about half of all control knobs use hex-head hardware. For these, you'll need a hex-key set. You can buy a set consisting of individual keys, individual keys in screwdriver-type handles, and even in fold-up "jackknife" sets. Prices range from very inexpensive to relatively expensive.

Nutdrivers are used in electronics work almost as often as are screwdrivers. Nutdrivers are available in both solid- and hollow-shaft configurations, as individual drivers with separate handles, individual drivers that plug into a common handle, and separate sockets that plug into a universal handle/shaft combination. The least expensive and most convenient way of putting together a set of nutdrivers is to buy one of the plastic-cased assortments sold by such companies as Xcelite, Vaco, X-acto, etc.

Stubby nutdrivers, such as Xcelite's No. PS-120 set, are handy to have

when you must work in tight places; they even have an extra-large slip-on handle for increased turning torque. Large-size "nut" drivers for volume-control and rotary-switch hardware allow you to install the large hex nuts without the danger of marring the control panel. Supplement your nutdriver lineup with a set of miniature precision drivers. These are the nutdriver equivalent of the set of jeweler's screwdrivers.

Vaco has an interesting all-in-one self-adjusting nutdriver that fits hardware ranging from $\frac{1}{4}$ " to $\frac{7}{16}$ " (6.35 to 11.11 mm). You simply press the driver head against the nut to be driven, and the proper "socket" automatically fits over the screw. This tool can save lots of time that might ordinarily be wasted as you hunt through a separate assortment to find the right driver for a given nut. It also has the advantage of requiring the space of only a single driver in your tool kit.

You'll find that a 6" or 8" (15.2 or 20.3 cm) adjustable wrench will suffice for most of your nut and bolt turning operations. However, there always comes a time when your working space is so restricted that the adjustable wrench proves useless. In this case, you'll really come to appreciate an assortment of ratchet box wrenches. In general, you'll need only two ratchet wrenches $\frac{1}{4}$ "- $\frac{5}{16}$ " and $\frac{3}{8}$ "- $\frac{7}{16}$ " (6.35-7.94 and 9.53-9.94 mm). You can, of course, buy individual box/open-end wrenches, but there is really no call for the added expense and the space and weight they will take up in your tool kit.

Soldering Equipment. Although it's not the only method of mechanically and electrically assembling a circuit, soldering still ranks as the most practical for the great majority of assembly projects. Since most modern



electronic components are small and either heat-sensitive or static-electricity-sensitive or both, the most practical soldering tool is a low-wattage soldering iron or pencil with a grounded tip. (If you have, or anticipate having to do, heavy-duty solder-



ing, figure on buying a 100/140-watt dual-heat soldering gun.)

Your soldering iron or pencil should be rated at 25 to 50 watts, with a good average rating of about 35 watts. Make certain that it is UL approved for safety insurance. Modular soldering pencils, with separate power handles, heat elements, and soldering tips, offer maximum flexibility. They allow you to change heat-element cartridges and/or tips to suit the work in hand. And if any one piece goes bad, only that piece need be replaced, which adds up to good economy.

Soldering tips are available in raw copper, iron-clad copper, and nickel-plated copper. The raw-copper tip is the least expensive but is prone to rapid pitting and wear and must be replaced fairly frequently. The plated tips, although initially quite expensive, last a long time and need little maintenance to keep them in good condition. Needless to say, plated tips are more economical and less troublesome in the long run than are raw copper tips.

Soldering tips are also available in a wide variety of configurations, ranging from a blunt pyramidal shape to a wide chisel to a very fine needle-like point. The blunt tips are best for heavy-duty soldering, using a 50-watt heat element. For more general soldering jobs, a medium chisel-point tip on a 35-watt element is best. But when you're dealing with IC projects where foil traces on the printed-circuit board and the component leads are very close, a fine chisel or needle point is best to minimize the possibility of solder bridges.

A starter soldering tool should include a 30-to-35-watt heating element and medium-chisel and needle-point plated soldering tips. You can build up a heat element and tip assortment as the need for them arises.

Most soldering irons and pencils do not have the grounded tips required for safe soldering of static-electricity-sensitive MOS devices. (Ungar's "Condensed Line" does.) However, it's a simple job to ground the tip of any soldering iron. Tightly wrap around the tip—away from the working point—a strip of 20-to-24-gauge copper and fasten to it with machine hardware a length of heavy-duty stranded hookup wire. Terminate the free end of the wire at earth ground, using a cold-water pipe.

Although the great majority of soldering irons are designed to be used on line power, there are now available a number of cordless irons. These soldering irons are powered by built-in rechargeable nickel-cadmium cells, which allows them to be used anywhere, even when line power isn't available. The cordless irons have small tips that heat up rapidly (5 to 10 seconds) and provide 100 or more solder connections, depending on the sizes of the connections. Although the tips attain a high temperature, the relatively small heating unit and tip greatly reduce the chance of lifting fine copper traces and pads from pc boards. Most cordless irons are equipped with a built-in work light and offer a limited variety of tip configurations.

For electronics work, use only 60/40 (percentage of lead to tin) rosin core solder. Select 16-gauge solder for general-purpose and 18- or 20-gauge solder for fine pc work. When solder-



ing any semiconductor device or heat-sensitive component, heat sink the component leads with spring clips, longnose pliers, locking forceps or tweezers, or alligator clips. Keep handy soldering aids with pointed, slotted, chisel, and brush tips.

For removing solder from crimped connections and pc boards, you can use a rubber-bulb-type solder sucker or a plunger-type sucker. The latter is generally the more efficient tool, though it is also the more expensive. The most thorough device for removing solder is the solder "wick" made of

finely stranded untinned copper braid. When the wick is placed over a connection and heated, the capillary action, or "wicking," that occurs between the fine strands takes up virtually all solder and eliminates most of the risk of delaminating fine copper pads and lines on pc boards.

Tools For PC Boards. The wrong way to drill the fine holes required in pc work is with a standard hand-type power drill. You'll only succeed in breaking the fragile bits and possibly gouging the board. An excellent tool for drilling holes in pc boards is the Micro Electronics Systems Mini Drill that can be either AA-cell or line powered, the latter with an ac adapter. The tool accepts bits ranging from No. 80 to No. 54 (0.343 to 1.4 mm).

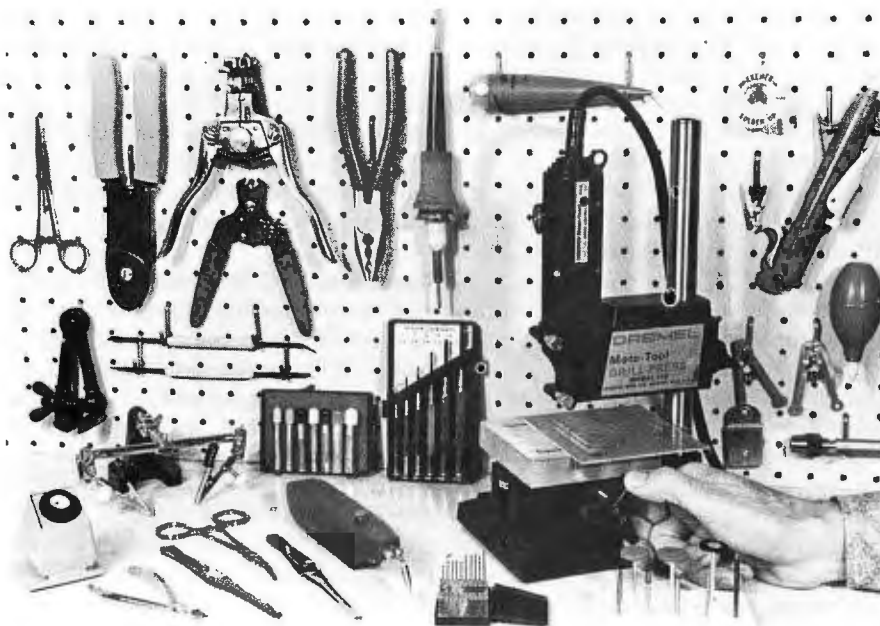
Another good tool for pc board work is the Dremel Moto Tool high-speed drill and grinder, which comes in



models ranging from the 0.5-ampere Model 260 to the heavy-duty variable 0.9-ampere Model 380. Light in weight, it is easy to manipulate and accepts drill bits ranging from No. 80 to No. 30 (0.129 to 3.26 mm), depending on which of three chuck collets are used. For maximum working convenience, you can convert the Moto Tool to a deluxe pc board drill press by mounting it in the No. 210 drill stand. Used in this manner, the Moto Tool will permit you to spot the bit on the smallest of copper pads with perfect accuracy.

An interesting new tool from Dremel is the Model 232 Moto-Flex, a high-speed drill and grinder with a 34" (0.86-m) flexible shaft and handpiece. This tool affords very precise control over hand-machining operations on the pc board. Its $\frac{23}{32}$ " (18.4-mm) diameter handpiece has ball bearings and accepts all Moto Tool collets and accessories.

With many accessories, these tools permit you to cut, score, or notch circuit boards using steel saws; cut off potentiometer and rotary switch shafts and screws with the cutoff



Tools for a well-stocked electronics workbench. Both common and special tools ease project construction.

wheel; and grind, debur, and polish other items. You can, for example, make inexpensive ground-plane boards using the No. 9909 router bit and Vector No. P138C circle pad cutter. (See "Perfboard Wiring Techniques," POPULAR ELECTRONICS, April 1976 for details.)

Special Tools and Aids. The fastest and lowest-cost perforated-board wiring method is with one of the wiring pencils, which eliminates wire cutting and stripping. You can interconnect any number of terminals with a single unbroken run and cut off the wire with the tip of the tool. You simply solder terminals through the insulation, which instantly vaporizes when heat is applied.

Automatic wire cutters/strippers, although rather expensive, can be a

real time saver when you have a lot of point-to-point wiring to do. These tools come with steel blades that do the cutting and stripping. If you don't mind first cutting your wires to size, one of the best strippers there is is the Alpha Model STRP-25 with *plastic* stripping blades. The plastic material is easily deformable to cut through insulation without nicking the wire. You can get thousands of strips from a single pair of blades. As the blades get used up on one size wire, they're still good for larger sizes. When the blades are finally used up, you simply inject new blades and start over again.

For holding and positioning pc boards and small electronic circuit modules, you can get a work-holding jig from X-acto or Brookstone. For detailed work, you'll want a work-inspection magnifier, preferably with a built-in fluorescent lamp, like the Luxo Model LFM-1.

You can easily damage the pins on DIP IC's when inserting or removing the devices from sockets. To play it safe, you can use either the GC Electronics No. 9481 Pul-N-Sertic insertion/removal tool or No. 9227 removal tool. For round transistors and IC's, use the No. 9216 Quick-Pick sleeve-type grippers from GC. (Incidentally, the Quick-Picks also serve as

excellent heat sinks for transistors and IC's during soldering operations.)

Among the handiest of tools, the locking forceps serve as both needle-nose pliers for light work and heat sinks when soldering. The GC Electronics tweezer forceps come in two lengths, with either curved or straight jaws. Three assorted tweezers are included in the GC No. 7960 kit, two of which are locking types to allow their use as heat sinks.

Building a project from scratch requires a number of tools not so far mentioned. These include a bench vise, set of drill bits, combination square, assorted files, hole reamer, center punch, nibbling tool, hacksaw, etc. Unusual tools, such as a pin vise, small hand vise, and razor saw, also come in handy. Many common and specialized tools are listed in the catalogs of Sears Craftsman; GC Electronics; Brookstone Co. (13 Brookstone Bldg., Peterborough, NH 03458); and Jensen Tools & Alloys (4117 N. 44 St., Phoenix, AZ 85018). Hobby centers are also good places to look for fine-quality precision tools.



A Word About Quality. Price and appearance are not always related to tool quality. High-grade hand tools are drop forged of various alloy tool steels, hardened and properly tempered. In the case of pliers, the tools should open smoothly and without erratic binding or looseness. Sight through and along closed jaws and cutting edges for proper alignment. Most pliers are made with the common lap-joint pivot that eventually loosens. You'll make a much wiser investment if you look for plier-type tools constructed with box-joint pivots that retain jaw alignment.

At all costs, avoid buying "bargain" pack tools or tools that are extremely low priced. Good and top-quality tools are rarely ever bargain priced; only tools that will fall apart or quickly wear out ever go on "bargain" racks. If you buy the latter, you'll only have to replace them in short order. It's better to buy the best when you can afford them than to build up a tool kit that will fail to do the job. A good rule of thumb is to stay with brand names that you know are of good quality. ♦



GC Electronics Quick Pick Tools (left) and IC remover (right), with Pul-N-Sertic semiconductor inserter and remover (center)—all very handy.

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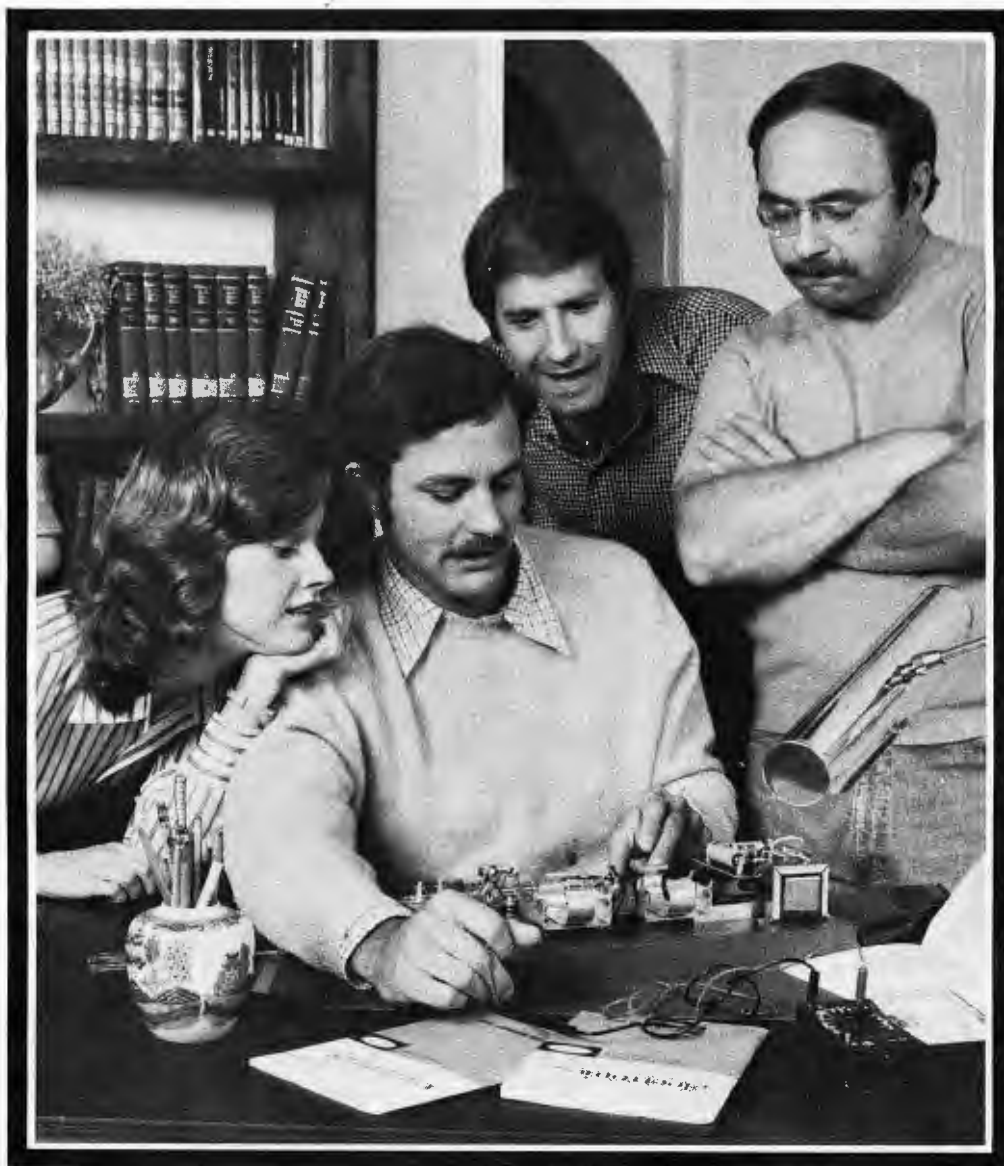


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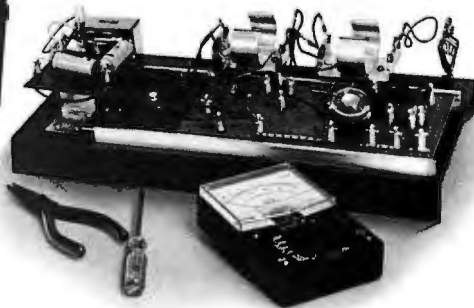
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BUILD THIS LOW-COST CAPACITANCE METER

*Five linear ranges
to 10,000 μF*



BY THOMAS MCGAHEE

WHEN a capacitor is connected to a constant-voltage source through a resistor, the charge on the capacitor increases *exponentially*. If the source supplies a constant current, however, the charge on the capacitor increases *linearly*. This linear charging principle is used here in the design of a capacitance meter which will measure values outside the range of most such meters. By using a constant-current source, the meter determines the time it takes to match the charge on the unknown capacitor to a known reference voltage. The meter has five full-scale ranges of 1,

10, 100, 1000, and 10,000 μF . On the 1- μF scale, values as small as 0.01 μF can be read easily.

How It Works. As shown in Fig. 1, D1, D2, R6, Q1 and one of the resistors (R1 through R5) selected by S1A provide five decades of constant current. With S2 in the position shown in Fig. 1, this current is shunted to ground via S2A. When S2 is placed in its alternate position, the constant current will be pumped into the unknown capacitor connected across BP1 and BP2, forcing it to charge in a linear fashion.

Op amp IC1 is connected as a com-

parator, with its noninverting (+) input connected to R8, which determines the reference voltage. When the voltage developed across the unknown capacitor, connected to the inverting input (-) of IC1, becomes a few millivolts higher than the preset reference voltage, the comparator output will switch from +12 volts to -12 volts.

The output of the comparator drives a constant-current source consisting of D3, D4, D5, R10, R11, and Q2. When S2A was switched to ground, so was S2B. This action shorts across storage capacitor C1, therefore the voltage across this capacitor is zero.

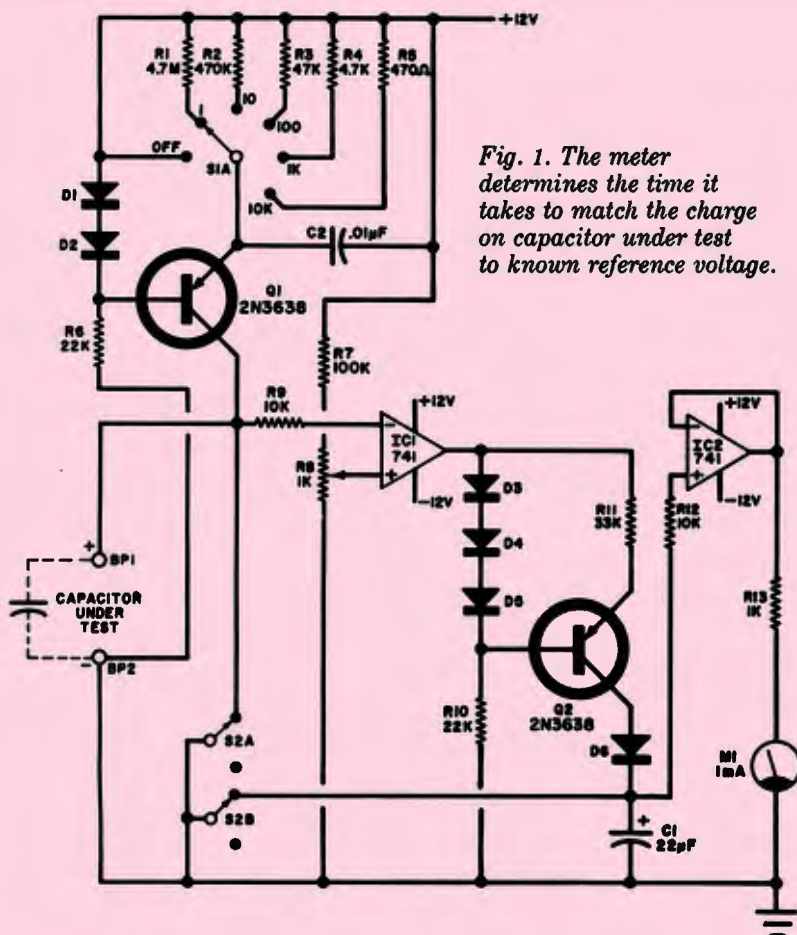


Fig. 1. The meter determines the time it takes to match the charge on capacitor under test to known reference voltage.

PARTS LIST

- BP1, BP2—Five-way binding posts (one red, one black)
 C1, C4—22- μ F, 35-volt electrolytic capacitor
 C2—0.01- μ F ceramic disc capacitor
 C3—220- μ F, 35-volt electrolytic capacitor
 D1 to D6—1N914 diode
 D7, D8—50-volt, 500-mA silicon rectifier
 D9, D10—12-volt zener diode
 IC1, IC2—741 mini-DIP case
 M1—0-1-mA meter (Radio Shack 22-052 or equiv.)
 Q1, Q2—2N3638 transistor
 R1—4.7-megohm, $\frac{1}{2}$ -w 5% resistor
 R2—470,000-ohm, $\frac{1}{2}$ -w 5% resistor
 R3—47,000-ohm, $\frac{1}{2}$ -w 5% resistor
 R4—4700-ohm, $\frac{1}{2}$ -w 5% resistor
 R5—470-ohm, $\frac{1}{2}$ -w 5% resistor
 R6, R10—22,000-ohm, $\frac{1}{2}$ -w resistor
 R7—100,000-ohm $\frac{1}{2}$ -w resistor
 R8—1000-ohm, pc-type trimmer potentiometer
 R9, R12—10,000-ohm, $\frac{1}{2}$ -w resistor
 R11—33,000-ohm, $\frac{1}{2}$ -w resistor
 R13—1000-ohm, $\frac{1}{2}$ -w resistor
 R14—560-ohm, $\frac{1}{2}$ -w resistor
 R15—470-ohm, $\frac{1}{2}$ -w resistor
 S1—Dp 6-pos. rotary switch (Radio Shack 275-1386 or equiv.)
 S2—Dpst or dpdt pushbutton or rocker switch
 T1—Transformer, secondary 12-V, 300 mA (Radio Shack 273-1385 or equiv.)
 Misc.—Suitable enclosure (Radio Shack 270-627 or equiv.), line cord, insulated wire, spacers, rubber feet (4).

When S2 is opened, the constant current flowing into C1 causes the voltage across it to rise linearly. When the voltage across the capacitor under test causes the comparator to switch, diode D6 becomes reverse biased, preventing C1 from charging any more. Since C1 only charges until the comparator switches, the voltage generated across it is directly proportional to the capacitance value of the unknown capacitor.

To prevent C1 from discharging while measuring its voltage, a high-impedance buffer, formed by IC2, is used. While this buffer draws very little current, it does draw some, and this results in a very slow downward drift

of the meter—but this drift is actually too slow to cause any problems. Resistor R13 and meter M1 make up a simple voltmeter readout of approximately 1 volt full scale. If desired, an external voltmeter can be used as long as it has a full-scale range of less than 8 volts. (If you use such an external meter, set R8 on the 1- μ F range, so that a known 1- μ F capacitor indicates 1 volt.) Capacitor C2 is used to prevent oscillation of the Q1 constant-current source, while R9 and R12 protect the op amps in case the power is turned off while the test capacitor and C1 are charged, otherwise they might discharge via the op amps, causing damage.

The power supply whose circuit is shown in Fig. 2, can supply sufficient current to power the meter.

Construction. The circuit can be built on the pc board whose foil pattern is shown in Fig. 3, along with the component installation on the nonfoil side of the board. Be sure to observe the polarity of the two electrolytic capacitors and the various diodes. The IC's are identified by a notch code.

The prototype was assembled in a 6 $\frac{1}{4}$ " by 3 $\frac{3}{4}$ " by 2" plastic box having a metal cover. The cover was drilled to accept M1, range switch S1, switch S2, and the two binding posts (BP1, BP2). Note that a red binding post was used for BP1 as this side is to be connected to the positive lead of the capacitor under test. The line cord exits through a small hole in the side of the plastic box.

Meter M1 is linearly calibrated to 1 mA full scale. Carefully open up the meter and using press-on type, or other printing medium, mark the scale "MFD" or " μ F."

The accuracy of the capacitance meter depends on two factors; the

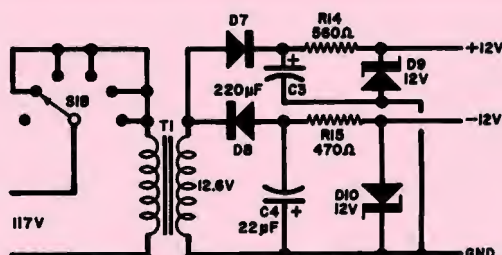


Fig. 2. Power supply delivers sufficient current for meter.

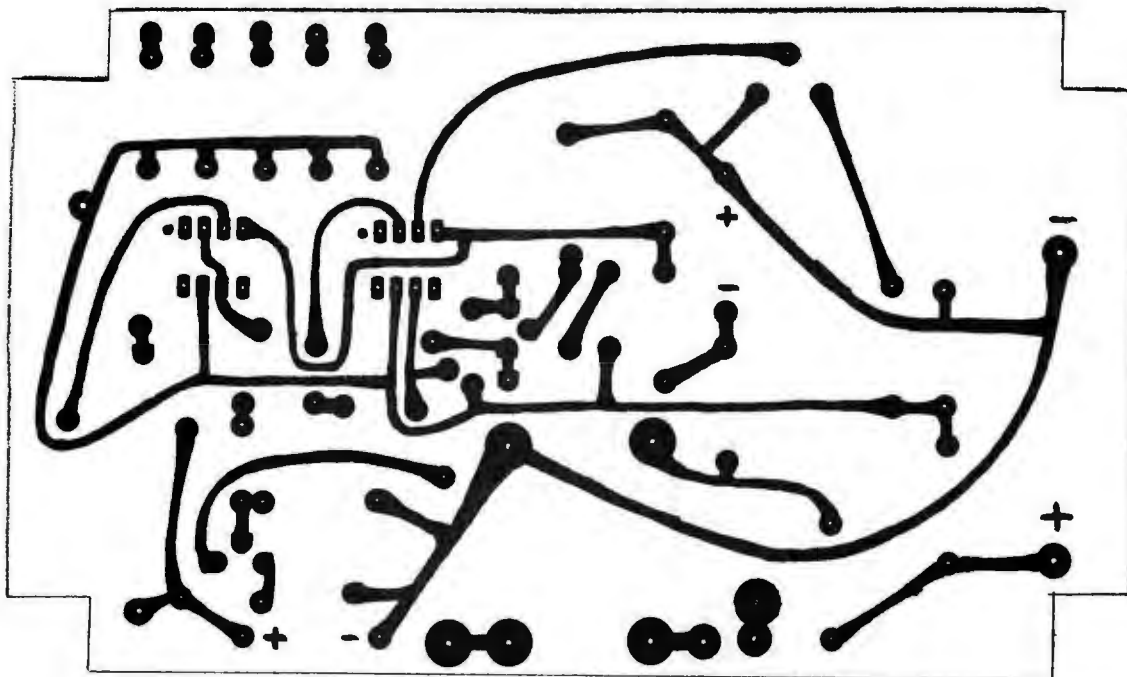
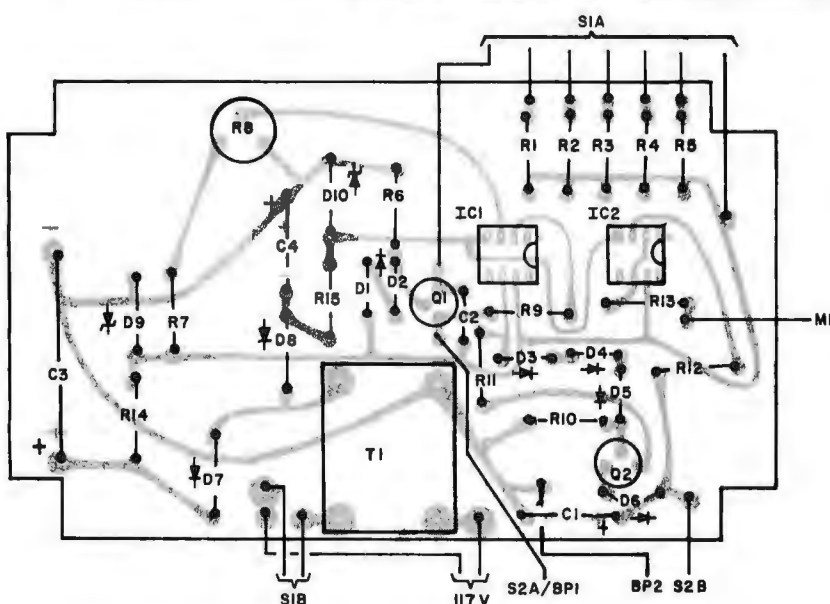


Fig. 3. Actual-size etching and drilling guide is above, component layout at left.



basic accuracy of the meter movement used and the accuracy of resistors $R1$ through $R5$. In most cases, the meter accuracy will be 3%, and experience has shown that, with 5% tolerance resistors, the overall accuracy is about 3%. Although this may sound strange, it is due to the fact that most 5% resistors made by the same company tend to be off tolerance by the same percentage, thus reducing the effective percent error between the resistors. Using 10% resistors yields about 6% accuracy.

Calibration. Before applying power to the capacitance meter, use a small screwdriver to set the meter pointer exactly to the zero mark.

Select a capacitor between 0.5 and 1.0 μF at 5% or better. This will be the "calibration standard." Connect this capacitor between $BP1$ and $BP2$ (positive side to $BP1$). Set range switch $S1$ to the "1" position (meter indicates 1- μF full scale). Operate $S2$ to remove the ground lead from the two circuits ($Q1$ collector and $C1$). The meter should start upscale and stop at some value. Reversing $S2$ should cause the meter to drop to zero volts. Flip $S2$ again and note the upscale value of the meter. Alternately flip $S2$ and adjust $R8$ until the meter indicates the exact value of the 5% calibration capacitor. The one calibration will suffice for all the other ranges. ♦

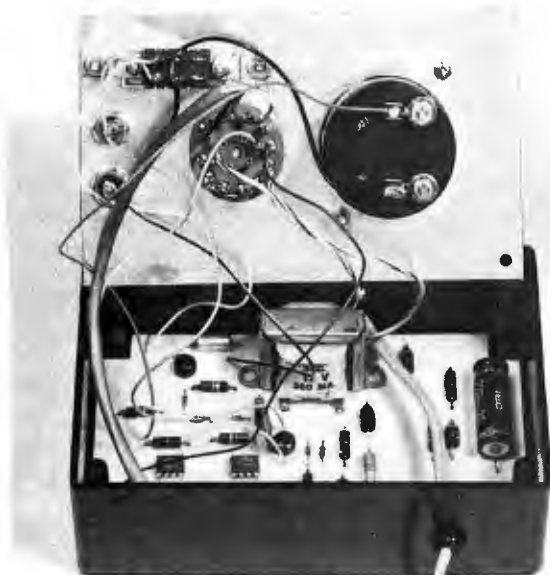


Photo shows how author's prototype was assembled in box.

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A Strobe Flasher for Night Cycling

Uses a high-voltage xenon flash tube and dc/dc converter.

ALL BICYCLISTS and car drivers are aware of the need for visibility when riding a two-wheeler at night or in fog. However, providing a clear indication of a cyclist's presence can be a real problem. Blinking incandescent lights can be used, but they put out only small amounts of light. The light described in this article uses a xenon tube to generate a bright flash that can be seen from a great distance—but is not intense enough to destroy a driver's night vision. Simple circuitry allows the project to be built at low cost, in a lightweight, compact package that can be secured to the bicycle or the rider's belt.

Principles of Operation. The light-producing element is a sealed glass tube containing two electrodes and filled with the inert gas, xenon. When a high voltage is applied to the tube, the gas ionizes. That is, some of the electrons are stripped from the xenon atoms. When the electrons and xenon ions recombine, the energy that caused them to separate is given up as light. If many atoms are ionized, the light output is intense.

Xenon flash lamps are usually operated in a pulsed mode. The intensity of their flashes gives good visibility, and their short duration keeps the average power applied to the tube low. How-

ever, the flash tubes require high voltages. In this circuit, a dc-to-dc converter supplies this high voltage, drawing power from two AA batteries. A capacitor stores charge which is needed for the large instantaneous flash current. To initiate ionization in the tube, a potential difference of about 4000 volts is required. This is developed by a trigger coil, or pulse transformer, which steps up the converter output.

About the Circuit. Transistor Q1, transformer T1, and their associated components comprise an oscillator which is the heart of the dc-to-dc con-

verter. When power is first applied, collector current builds up until the ferrite core of *T1* saturates. At this point, base drive is removed from *Q1*, the transistor cuts off, and flux in the core decays. Then the cycle repeats itself again.

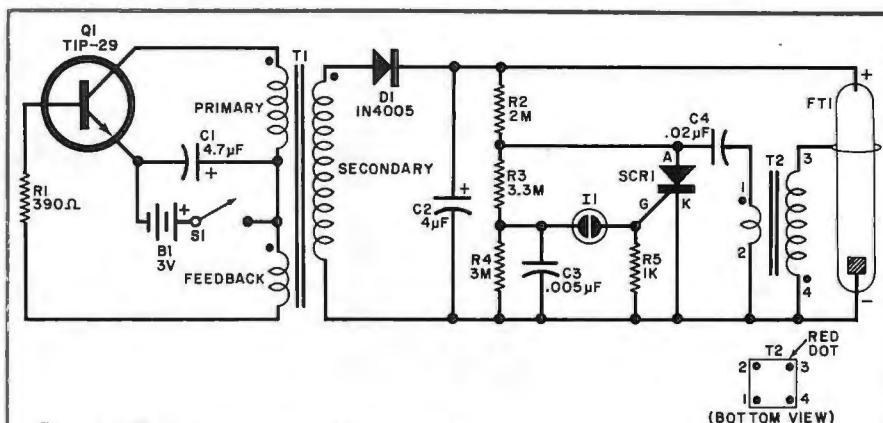
On the other side of *T1*, high voltage pulses developed across the secondary are rectified by *D1*, and charge *C2* to +250 volts. The voltage divider composed of *R2*, *R3*, and *R4* charges *C3* to 90 volts and *C4* to 200 volts. The time constants associated with these capacitors are small, so the voltages across *C3* and *C4* can be assumed to be proportional to that across *C2*.

When the potential across *C3* reaches approximately 90 volts, neon lamp *I1* fires and discharges *C3* through the gate of *SCR1*. This causes *SCR1* to turn on, and the charge stored in *C4* is dumped into the primary of *T2*, the trigger coil. Because of *T2*'s high step-up ratio, this surge of current induces a potential difference of several thousand volts across the secondary. In turn, the flashtube fires, creating a bright flash of light as the charge stored in *C2* flows through the tube. When *C2*'s charge is depleted, the tube stops conducting and goes dark. Then the rectified pulses from *D1* start to charge up the capacitors, and the cycle begins again.

The flasher requires only two or three volts to function. Two penlight (AA) cells make a lightweight power source, but since current drain is 250 to 300 mA, carbon zinc cells should be used only if the flasher is intended as a back-up safety device in extreme circumstances. However, two alkaline AA cells should provide about six hours of intermittent operation. If the flasher is to be used frequently, rechargeable nickel-cadmium batteries should be installed. They will give about two hours' use to a charge. (Of course, rechargeable or nonrechargeable C or D cells can be used if more extensive use is contemplated.)

Most of the components can be obtained from any electronic parts store, including flash tube *FT1* and trigger coil *T2*. However, the converter transformer *T1* must be wound on a Ferroxcube 2616-F1D bobbin and uses two Ferroxcube 2616-PL00-3C8 pot core halves. These parts are available from some industrial distributors, and a mail-order source is included in the parts list.

Construction. The flasher can be



Two 1.5-V batteries power the converter which drives the flashtube and SCR trigger circuit.

PARTS LIST

B1—Two 1.5-volt cells in series (see text)
 C1—4.7-μF, 10-V electrolytic capacitor
 C2—4-μF, 450-V electrolytic capacitor
 C3—0.005-μF, 500-V disc ceramic capacitor
 C4—0.02-μF, 500-V disc ceramic capacitor
 D1—1N4005 diode
 FT1—Xenon flash tube (Radio Shack 272-1145 or equivalent)
 I1—NE-2 neon bulb
 Q1—TIP-29, HEP S5000 npn plastic power transistor or equivalent
 The following are ¼-watt, 10% tolerance resistors:
 R1—390 ohms
 R2—2 megohms
 R3—3.3 megohms

R4—3 megohms
 R5—1000 ohms
 S1—SPST switch
 SCR1—400-volt silicon controlled rectifier (Radio Shack 276-1000 or equivalent)
 T1—see text
 T2—4000-volt trigger coil (Radio Shack 272-1146 or equivalent)
 Misc.—Printed circuit or perforated board, solder, hookup wire, No. 34 enamelled wire, No. 28 enamelled wire, machine hardware, circuit board spacers, suitable enclosure, battery holder, standoff insulator, silicone cement, solder, etc.
 Note—The Ferroxcube 2616-F1D bobbin and two 2616-PL00-3C8 ferrite pot core halves are available for \$3.00 (first class postage paid) from Elna Ferrite Laboratories, Inc., Box 395, Woodstock, NY 12498.

built on a printed circuit or perforated board, and housed in any enclosure of sufficient size. The prototype was built in a small plastic box with a transparent top which protects the flash tube without obscuring its light output.

No matter which arrangement is chosen, the first step in constructing the flasher is to assemble *T1*. It is wound on a nylon bobbin that will be inserted into a two-piece ferrite pot core. Begin with the secondary. Allow a few inches of No. 34 enamelled wire to extend from a slot in the bobbin, and attach a "flag" of masking tape to the end of the wire. Mark the tape with an "S." This will allow you to keep track of the start of the secondary winding, which is essential to proper phasing. Secure the wire to the bobbin with a piece of electrical tape, and then wind 350 turns, keeping each layer even. When you have finished, cover the winding with electrical tape, and leave a few inches of wire free to serve as a connecting lead for the "finish" end of the secondary.

The primary will be wound next, using No. 28 enamelled wire. Use a masking tape flag marked "P" to identify the start of the winding, and wind 16 turns in the same direction as you

did for the secondary. When the primary is completely wound, cover it with a layer of electrical tape. As before, leave a few inches of wire free at both ends of the primary. Finally, wind the five-turn feedback winding in the same direction as the other two. Use No. 28 enamelled wire, identify the start of the winding with a tape flag marked "F," and cover the completed bobbin with a layer of electrical tape. Again, leave a few inches of lead length on each side of the winding.

Insert the bobbin between the two pot core halves, and mount the transformer on the project board using #6-32 machine hardware. The ferrite core is very brittle, so the mounting hardware should be no more than finger tight. Use a daub of silicone cement to secure the nut to the board.

The flashtube should be mounted so that it can be seen and is somewhat protected from shock. The author mounted his flashtube on the circuit board using its leads and a standoff insulator. Note that the electrode composed of wire mesh is the cathode. Trigger transformer *T2* should be positioned near the flashtube. The rest of the components can be mounted in any convenient

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manner. It is wise to leave the transformer leads long, as a mistake in the direction of a winding, or improperly identifying the start of a winding, will require a phasing change involving the reversal of one or more windings.

Checkout and Troubleshooting.

When you have completed building the project, double check all wiring, and then turn the unit on. The flashtube should flash about once each second, and an audible whistle should be heard near T1 as the dc-to-dc converter oscillates.

If no whistle is heard, measure the battery voltage and current with a high-impedance multimeter. If no current is being drawn from the battery, check the wiring to T1, Q1, R1, the battery, and switch S1. If current is being drawn, try reversing either the primary or feedback winding of T1, but not both!

The converter might oscillate but the flashtube won't flash. In that case, measure the voltage across C2. Although current is limited, the capacitor's voltage can give you an unpleasant shock, so be careful! A reading of 250 to 300 volts is normal. But if the voltage is below this level, disconnect R2 and the anode of FT1 from the positive plate of C2. If the voltage is now correct, the problem is located in the trigger circuit for the flashtube. If the voltage is low but not zero, try reversing the secondary winding of T1. Zero voltage points to incorrect wiring or a defective D1 or C2 component.

When the voltage across C2 is correct but there is no flash, the trigger circuit must be examined. Measure the voltage between the anode and cathode of SCR1. You should obtain a reading of 200 volts or so. If you do, short these two points with a jumper. The tube should flash as you do this. If it doesn't, either it or the trigger coil is defective. Other possibilities are a faulty SCR or trigger component (T1, etc.) or incorrect wiring of that part of the circuit that generates the trigger.

Final Thoughts. If desired, small leather straps can be secured to the flasher enclosure to serve as belt loops. The unit is small enough to be mounted either on the bicycle or on the cyclist's arm or leg. It can also be taken along for hikes on dark country roads. You will probably find many other applications for this handy little bicycle flasher.

FIND THE HIDDEN ELECTRONICS WORDS

THERE are at least 59 electronics words, acronyms, or prefixes, hidden in the diagram at the right. You can locate them by reading forward, backward, up, down, or diagonally. They will always be found in a straight line, and no letters are skipped. The term "nano" has been circled to give you an idea of how to proceed. See how many of the known words or acronyms you can locate before you resort to the solution which is on page 105. If you find some that we didn't, good for you !

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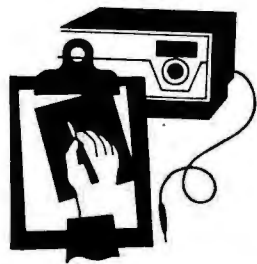
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Phono cartridges from Micro-Acoustics are unlike any other cartridges we know of in that they use electrets as transducing elements. The electret combines the advantages of magnetic and piezoelectric cartridges, with few of the disadvantages of either. The new Model 2002e cartridge is an updated version of the Model QDC-13 introduced a couple of years ago. Our tests proved it to be an outstanding cartridge in almost every respect.

The latest entry into the Phase Linear line of power amplifiers is the Model 200. This new "baby" amplifier is rated at a mere 105 watts/channel. It has the same styling, construction, and quality of performance of other Phase Linear products.

—Julian D. Hirsch

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years. In essence, it is a combination of the digital computer technology that made possible the electronic calculator and a deluxe direct-drive, two-speed record playing system. It comes with a high-quality tonearm that is fitted with a modified top-of-

the-line ADC Model XLM MkII phono cartridge.

On the front panel of the player's base is a row of 23 buttons similar to the keys on a calculator and four small rotary controls. The controls are for turning on and off the power, vernier adjustments of the 33 $\frac{1}{3}$ - and 45-rpm speeds, and setting the sensitivity of the player's unique sensor system. The buttons control all speed, record indexing, and track selection opera-

tions. In addition, the system comes with a remote-control facility that duplicates most of the controls on the player itself.

The Accutrac 4000 comes ready to play, mounted on a walnut base and with the cartridge installed. It measures 18 $\frac{1}{2}$ "W \times 17 $\frac{3}{8}$ "D \times 6"H (47 \times 44.1 \times 15.2 cm) and weighs 20 $\frac{1}{4}$ lb (9.2 kg). It sells for \$499.95.

General Description. The record player has 14 TRACKS buttons labelled from 1 to 13 and ALL. To play a disc from the beginning, the ALL button is pressed to start the platter revolving. (Normally, the player comes on at 33 $\frac{1}{3}$ rpm and is indexed for a 12" disc when power is applied. The buttons need not be touched unless 45-rpm discs are to be played or you desire to play tracks out of sequence.)

The control buttons have the light, positive tactile "feel" of the keys on a good pocket calculator. When the PLAY button is pressed, the tonearm moves to the lead-in groove of the disc, pauses, and slowly descends to the surface of the disc. After playing through to the end of the disc, the arm lifts and returns to its rest position, shutting off the motor.

Where the Accutrac 4000 differs from other record-playing systems is in its ability to allow you to play the various bands on a disc in any desired sequence and to repeat bands on command. When the PLAY button is pressed, the tonearm moves inward until it comes to the beginning of the first band selected, pauses for a few seconds, and lowers to the disc's surface. After playing the band, the arm lifts and returns to rest and again scans inward until it locates the beginning of the second band selected. The process repeats until all selected bands have been played. Then the player automatically shuts off.

The memory of the control system can store up to 24 program commands. Hence, bands can be repeated as desired up to a total of 24 times. Even the ALL button can be pressed 24 times, if that is what you want.

The REJECT button allows you to bypass any selection to go on to the following selection. The REPEAT button allows any selection being heard to be played again. If you wish to hear a band again from its beginning before it is ended, you press REPEAT and REJECT. The CUE button alternately raises and lowers the tonearm. (The audio outputs are muted whenever the

POPULAR ELECTRONICS

pickup is off the surface of the disc.) To stop play at any time, you press CLEAR, which wipes the memory clean and returns the tonearm to its rest position as before.

The manner in which the player locates the programmed bands is as intriguing as its control system. Built into the special Model LMA-1 cartridge are a LED and a photocell. The LED focuses an infrared beam on the record's surface, while the photocell intercepts the reflected light. The light is scattered by the grooves so that little of it reaches the photocell. However, the dead band between selections on the disc reflects sufficient light to the photocell to signal the computer circuits that the pickup has passed from one band to another.

The number of times the signal is received is compared with the information stored in the memory system. When the pickup reaches the beginning of the next programmed band, it stops and holds its position for a few seconds to average out any record eccentricities. The tonearm then descends to the record's surface. Since the dead bands can vary considerably in width from one disc to another, it may be necessary to adjust the sensitivity of the positioning system with the SENSOR control.

The system can also be played manually. When the tonearm is raised, it can be moved laterally, against some friction from the drive clutch, to any desired position. Pressing CUE then starts the turntable and lowers the tonearm. CUE can also be pressed while the arm is in its rest position, which then frees the arm to be moved and cued without resistance. ADC stresses that the tonearm is completely free while it is playing a disc because the servo-motor drive is disengaged by a clutch when the pickup is lowered.

Transparent and translucent discs cannot be played automatically because they do not reflect enough light to the photocell to trigger the automatic circuits. These discs must be played either manually or from the beginning in the ALL mode. Discs that have a raised and tapered rim can cause the pickup to overlook the first band and set down one track farther in than desired. If this occurs, it is necessary to make allowance for the fixed error when programming the mechanism.

The remote-control system is a unique feature of the Accutrac 4000
OCTOBER 1976

player. A small spherical optical sensor can be placed anywhere within 12' (3.7 m) of the turntable, into which it plugs. The small hand-held transmitter has buttons on it that duplicate all the TRACK and CONTROL buttons on the player itself. When the transmitter is pointed at the sensor and any button is pressed, a coded ultrasonic signal is sent to the receiver. The program is entered into the memory system, and a red light on the sensor winks to indicate that the command has been received by the system.

Laboratory Measurements. The turntable had the low rumble and flutter one would expect from a good direct-drive system. Rumble was 42 to 44 dB down unweighted and 62 dB down with ARLL weighting. Wow and flutter were each 0.04% unweighted rms. The speeds were exact when the built-in strobe pattern was stationary. They could be varied over a range of +2.6% to -2%. The speeds did not change when the line voltage was varied between 95 and 135 volts.

When set to the recommended 1-gram mark, the tonearm's tracking force measured 1.05 grams. The lateral tracking error was less than 0.5°/in. for radii between 3" and 6" (7.62 and 15.24 cm). It rose somewhat at smaller radii but remained within acceptable limits throughout the record area.

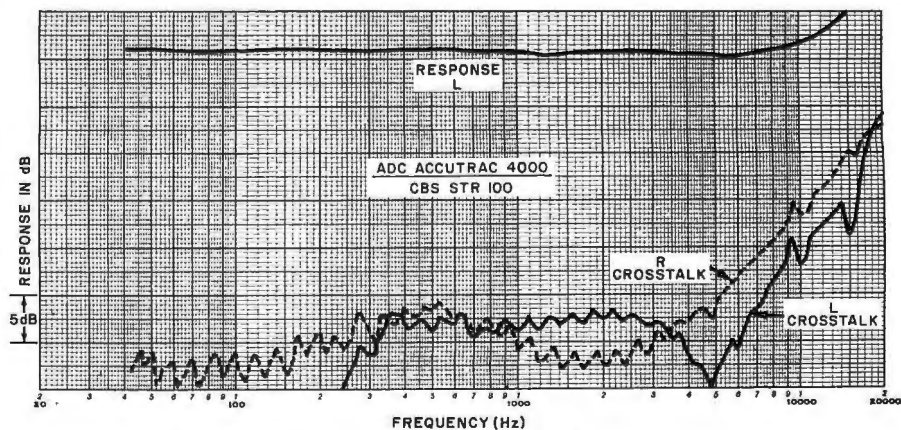
The antiskating dial had to be set considerably higher than the tracking force (typically 3 grams for a 1-to-1.5-gram tracking force) to provide equal playback distortion in both channels. The descent of the tonearm, under control of the cueing system, required 2 to 3 seconds. There was no lateral drift. The time required for the pickup to begin playing any selection after the PLAY button was pressed was about 7 seconds, almost half of it in the descent phase.

The cartridge was able to play most music records at a 1-gram tracking force without difficulty. The tracking at velocities exceeding 18 cm/s was poor at 1 gram. It was greatly improved by using the maximum recommended 1.5-gram force. At this low force, the IM distortion of the cartridge, at less than 2%, was about as low as any we have measured, even at the 27.1-cm/s maximum velocity of the Shure TTR-102 test record. The 10.8-kHz tone burst test of the Shure TTR-103 record indicated low distortion up to 20 cm/s and acceptable levels even at 30 cm/s.

Our other tracking test records (Fairchild 101, Cook 60, and German High Fidelity Institute) confirmed the importance of using a 1.5-gram tracking force. (On the German record, only the 60-micron band could be played at 1 gram, while the 80-micron band could be played at 1.5 grams.) The output of the cartridge was 4.1 mV on one channel and 3.55 mV on the other channel, measured at a 3.54-cm/s velocity. The vertical stylus angle of 28° was somewhat greater than we have measured on other cartridges. The bass resonance of the tonearm and cartridge was at 9 Hz at an amplitude of 9 to 10 dB. Since the cartridge is fairly massive, this indicates that the arm is commendably low in mass.

The frequency response of the cartridge was flat within ± 1 dB up to 10,000 Hz. It rose at higher frequencies to about +5 to +6 dB at 20,000 Hz. Channel separation was an excellent 30 dB in the midrange and 12 to 15 dB at 20,000 Hz. When we played the Shure "Audio Obstacle Course—Era III" record, it was necessary again to use a 1.5-gram tracking force to enable the cartridge to track all sections except the highest level of the sibilance test.

User Comment. Our measurements



Response of left channel and crosstalk in both channels.

and listening tests confirmed the excellence of the Accutrac 4000 as a record player. The rising high-end response of the cartridge is not likely to be heard as a brightening of the sound. Most speaker systems are not strong performers in the uppermost octave, and many amplifiers lose 1 or 2 dB of top-end response in phono operation due to interaction with cartridge inductance. To our ears, the ADC cartridge sounded clean.

The computer control system worked exactly as claimed, exhibiting all the strengths and weaknesses pointed out in the instruction manual. We expect that with at least 95% of the

records we have seen, the optical track locating system will work perfectly. With most of the rest, only a simple readjustment of the SENSOR control will be required.

Since the tonearm need never be touched, especially when it is in a position to contact the record, it would seem well nigh impossible to damage a record with this player. Furthermore, the servo-controlled tonearm sets down more accurately and gently than would be possible by hand. The remote-control system also worked perfectly. The spherical remote receiver survived a 3' (1-m) drop to a concrete floor without suffering either

functional or physical damage.

If used properly, this record player can greatly enhance both the safety and convenience of playing records, with none of the compromises inherent in record changers or some other semiautomatic turntables. Considering what this player does, even the price is reasonable. A good semi-automatic, direct-drive player would cost at least \$300, and the ADC cartridge costs \$100. This means that with the Accutrac 4000, you get the computerized memory and remote-control systems for a mere \$100. All things considered, we feel this player gives good dollar value.

CIRCLE NO. 80 ON FREE INFORMATION CARD

MICRO-ACOUSTICS MODEL 2002e PHONO CARTRIDGE

Improved electret transducer features low cartridge mass.



Cartridges from Micro-Acoustics are noted for their use of electrets as transduc-

ing elements. (The electret is a permanently polarized plastic capacitor whose capacitance is varied by mechanical flexing to produce a change in voltage across its terminals.) As used in the Model 2002e cartridge, the stylus cantilever is coupled to a pair of electrets as a "resolver" (yoke) so that stylus deflection by either stereo channel acts on only the corresponding electret.

The cartridge uses a beryllium stylus cantilever, which results in a very-low-mass, rigid moving system. Mounted on the free end of the cantilever is a 0.2×0.7 -mil diamond stylus. Among the specifications for this cartridge are: frequency response within ± 1.5 dB from 5 to 20,000 Hz; 30-dB nominal channel separation at middle frequencies; and 3.5-mV/

channel output at 5 cm/s recorded velocity. The rated tracking force is 0.7 to 1.7 grams. Any load resistance from 10,000 to 100,000 ohms and capacitance from 100 to 1500 picofarads is satisfactory.

The retail price of the cartridge is listed as \$115.

General Description. As with ceramic elements, the electrets used in the cartridge are amplitude-responding devices and have very high electrical impedance. Loading with a relatively low resistance—on the order of a few thousand ohms—reduces the cartridge's output voltage to that of a typical magnetic cartridge and converts its amplitude response to a velocity response. This makes the cartridge fully compatible with the input requirements of any magnetic phono preamplifier.

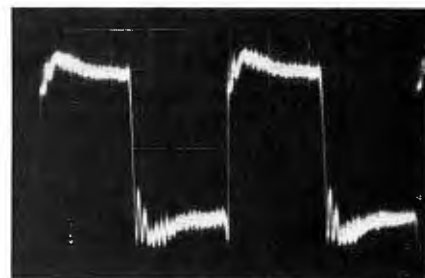
One of the advantages the electret has over the magnetic system is its inherently low mass. Since there is no heavy magnetic structure, the stylus is not required to move a piece of magnetic material. Because the cartridge has no internal coils, magnets, or pole pieces, it weighs much less than the typical magnetic cartridge. In fact, extra plastic had to be added to the cartridge's housing so that it could be balanced by existing tonearms. Nevertheless, the cartridge's 4-gram weight is considerably less than that of the magnetic cartridge, which usually weighs about 7 grams.

Several other advantages result from the use of the electret. With no coils, the cartridge is not susceptible

to magnetic hum pickup. Although the very high impedance of the electret might appear to make it subject to electrostatic hum induction, it is internally loaded with a 4000-ohm resistor so that hum can be induced only when the finger lift is being touched on tonearms that have unshielded heads for the cartridge.

The frequency response of the cartridge is virtually unaffected by external loading, including long signal cables. Unlike most magnetic cartridges, which rely on coil inductance and load capacitance to compensate for the high-frequency resonance of the generating system and to flatten the frequency response, the Model 2002e achieves its flat response by reducing moving mass. This places the resonance far above the audible range. Mechanical damping is built into the cartridge to control the resonant rise.

Finally, it is claimed that the constant load presented to the amplifier input reduces high-frequency noise in the phono system. (The impedance of a magnetic cartridge rises with frequency and can cause an emphasis in high-frequency noise.) Also, the purely resistive output impedance of the cartridge cannot interact with preamplifier equalization to modify its



Output from square-wave test.

high-frequency response, as occurs with most magnetic cartridges and amplifiers.

Laboratory Measurements. Using the CBS STR100 test record, we plotted a frequency response of within ± 1 dB over the 40-to-20,000-Hz range of the record for the new cartridge. The channel separation measured 20 to 25 dB at the middle frequencies, 15 to 20 dB at 10,000 Hz, and 5 to 8 dB at 20,000 Hz. The output of the cartridge at 3.54 cm/s was 3.25 mV on one channel and 2.8 mV on the other channel. The vertical angle of the stylus was 20°, which is the industry standard.

We played a number of high-velocity test records to determine the optimum tracking force for the cartridge. Under most conditions, 1 gram was sufficient; at this force, the 70-micron level of the German Hi-Fi Institute record could be tracked. However, at 1 gram tracking force, the IM distortion measured with the Shure TTR-102 test record was slightly high, between 1.5% and 3% up to about 19 cm/s. It rose abruptly at higher velocities, where the cartridge mistracked. An increase to a 1.2-gram force allowed the cartridge to track all levels of this record, with distortion typically about 1% up to 25 cm/s and only 2% at the record's maximum of 27.1 cm/s. The 80-micron level of the German record was playable at 1.2 grams tracking force.

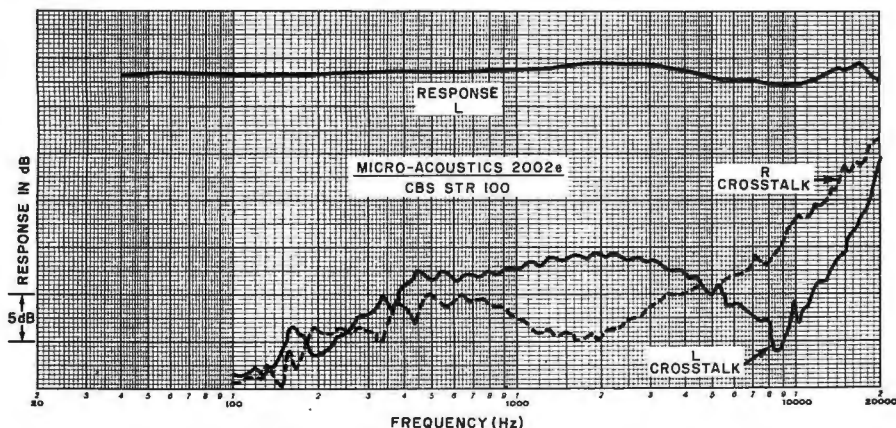
The 10,800-Hz tone-burst tracking test of the Shure TTR-103 record revealed low distortion even at 1 gram (only 1.7% at 30 cm/s), but an increase to 1.2 grams dropped this to a very low 1% figure. These tests were confirmed subjectively with the Shure "Audio Obstacle Course—Era III" record. At 1 gram, there was slight mistracking of the highest levels of the sibilance and

bass-drum sections, but at 1.2 grams, the cartridge tracked the entire record without difficulty.

Tests with the CBS STR112 test record produced a good square-wave output, with low-level ringing visible over most of the top of the waveform. The ringing occurred at about 35,000 Hz, which is the mechanical resonance of the moving system. This is about an octave higher than that of most other fine phono cartridges. With the cartridge installed in the relatively massive tonearm of a Philips record player, the low-frequency resonance was in the safe 7-to-8-Hz region. (Many cartridges resonate as low as 6 Hz in this tonearm.) In a widely used Dual record player, the resonance was at 9.5 Hz, an almost ideal frequency. These measurements clearly illustrate the advantage of low cartridge mass, since tracking of warped records can be severely impaired by a tonearm resonance below 7 Hz or so.

User Comment. The Model 2002e is an improved version of Micro-Acoustics' Model QDC-1e cartridge, which it replaces. The principal changes inherent in the new cartridge are an increase in stylus compliance and reduction of its moving mass (beryllium is used instead of aluminum for the cantilever) and reduction of the total mass of the cartridge.

Having used a Model QDC-1e for some time, we were in a good position to appreciate the improvement in the Model 2002e cartridge. The new cartridge tracks at a slightly lower force than its predecessor's 1.5 grams. The Model 2002e can actually be used with excellent results at 1 gram, where it is the equivalent of the Model QDC-1e operating at 1.5 grams. However, we feel that an increase to 1.2 grams is



Left-channel response and left and right crosstalk.

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worthwhile, since it makes the Model 2002e one of the best tracking cartridges on the market.

The flat response and low distortion of the new cartridge are outstanding. The channel separation is more than adequate, although it does drop off considerably at the very high frequencies. We listened carefully to the audible amplifier hiss with this cartridge and several fine magnetic cartridges with inconclusive results. When the

gain was set for equal volume from both cartridges, the hiss was sometimes less with the Model 2002e, sometimes, the same, but never was it greater than that of the magnetic cartridges that we tested.

We were struck by the total absence of hum pickup. Hum is not always audible as such, but with magnetic cartridges, it is usually present to the extent that its removal can be detected.

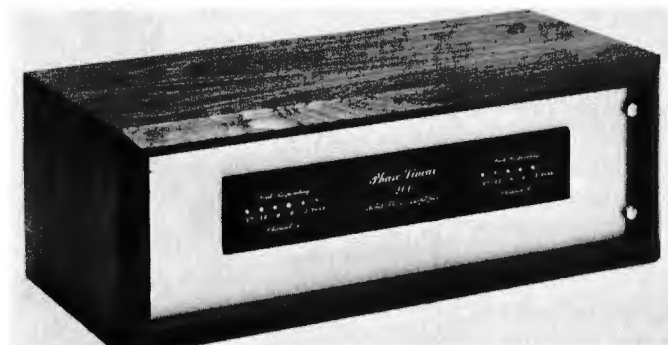
All in all, the sound of the Model

2002e cartridge was smooth and unstrained. The cartridge can track just about anything on today's records at 1.2 grams and will play warped records that might prove too much for some cartridges in a given tonearm. Finally, the cartridge is *quiet*. Even at the highest listening levels, lifting the tonearm from the record results in total silence from the speaker systems driven by most good amplifiers.

CIRCLE NO. 81 ON FREE INFORMATION CARD

PHASE LINEAR MODEL 200 BASIC POWER AMPLIFIER

High-quality, moderately high power at "popular" price.



Phase Linear's high-power audio amplifier technology, as used in the Mod-

els 400 and 700 amplifiers, has been applied to a more popular price and power range in the new Model 200. The new amplifier is rated to deliver 105 watts/channel with both channels driven into 8-ohm loads from 20 to 20,000 Hz at less than 0.25% total harmonic distortion (THD). A signal level of 1.5 volts across the 18,000-ohm input drives the amplifier to its rated output power. The output transistors are protected by current-limiting circuits, and a fast-acting relay disconnects the speaker systems during start-up and turn-off and in the event of an internal failure that could damage the speakers.

The amplifier matches the styling of other Phase Linear amplifiers. It has a light colored brushed-gold front panel that measures 19"W x 5½"H (48.3 x 14 cm). Overall depth is 8¾" (22.2 cm), much of which is taken up by the large heat-sink fins. The power transformer is at the right rear, but the lightweight 16-lb (7.3-kg) amplifier prevents the off-center weight distribution from causing handling problems.

The retail price of the Model 200 amplifier is \$389.00.

General Description. On the left side of the rear apron are insulated spring-clip connectors for hooking up the speaker systems, two phono-jack inputs, and two slide switches. One switch is for increasing the sensitivity of the LED power display on the front panel by 10 dB. The other switch is identified as a VELOCITY FEEDBACK switch with NORMAL and IN positions. According to the instruction manual that comes with the amplifier, the IN position reduces the current feedback in the amplifier by some 5 dB and raises the overall gain by the same amount. (Phase Linear's only explanation for this feature is that "some listeners may prefer" to hear sound with less feedback.)

Across the center of the front panel is a plastic-covered cutout about the size of the dial window of a tuner. Its only apparent purpose is to provide a means for placing the identification "Phase Linear 200 Solid State Amplifier" on the unit. On each side of the window is a graduated peak-responsive power indicator system made up of six LED's for each channel. The LED's are labelled PEAK, -3, -6, -9, -12, and -20 dB. PEAK corresponds to the maximum rated power of 105 watts or to 10.5 watts if the SENSITIVITY switch on the rear apron is set to its -10 dB position. The manual

gives the power equivalents (across an 8-ohm load) for each channel for the other LED's in the display. The table contains some inconsistencies—the sensitivity increase is given as 10 dB for the two highest levels and 6 dB for the others—but the LED's are adequate for monitoring the approximate power output of the amplifier.

Laboratory Measurements. When we operated the amplifier at one-third its rated power for an hour, it became quite hot to the touch. However, this did not affect its operation. Fully heated, the amplifier delivered 162 watts/channel at the clipping point into 8-ohm loads with both channels driven simultaneously at 1000 Hz. The 16-ohm output power was 100 watts, and the 4-ohm output power, due to the current-limiting circuits, was measured to be 115.6 watts.

The 1000-Hz THD was about 0.01% or less at most power levels between 0.1 watt and 75 watts. It reached 0.02% at the rated output and 0.25% at 140 watts output. The IM distortion was between 0.01% and 0.05% from a few milliwatts to the rated output power. It was 0.24% at 130 watts.

At the rated 105-watt output, the distortion was well below 0.1% from 20 to 20,000 Hz. It measured about 0.02% at most frequencies. At reduced-power outputs, 3 and 10 dB down, it was even less, measuring typically about 0.01%. An input of 0.52 volt drove the amplifier to a reference 10-watt output, where the hum was a very low -93 dB, referred to 10 watts. When velocity feedback was switched in, the gain increased so that about 0.38 volt at the input produced a 10-watt output, but the noise level rose slightly to -82 dB. The distortion was only slightly affected by the feedback change. The gain of the left channel, on which these measurements were based, was 1.4 dB greater than in the right chan-

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At first people thought that perhaps owners of our system were just a bit shy because they were outnumbered at local computer club meetings. But then as the number of owners rose it became clear that this was not the problem. And it wasn't that they were unsociable or anything like that; they were simply just bored because they had nothing to talk about.

Here they were, just sitting there while all the other members with other brands of computers exchanged data on circuit board errors, secret schemes of adding extra bypass capacitors to make the thing reliable, tricks to keep the clock phases from overlapping, corrections to manual errors and other fun subjects. Can you imagine the frustration this caused? All our customers could do was to sit and be bored. They had nothing to talk about.

Our 6800 has an internal monitor ROM that automatically puts the bootstrap loader in memory and refers control to the terminal, when you power up. This feature deprives you of the chance to tell sad stories of how many

times you had to go back and flip the console switches before you got the loader program in right. Since you can do machine language programs directly from your video terminal or teletype in hexadecimal form, you will not have a chance to exchange horror stories with your friends about how you forgot the last zero when you entered 10100110 from the console on your 374th Byte and messed up the program that had just taken you two hours to put into memory. It just isn't fair.

Since we use full buffering on all data, address and control lines on all boards in our system and since we use low power 2102 static memories in our system, there are no noise sensitivity problems that can lead to hours of fun trying to figure out why a program "bombed". Dynamic memories that some others use can drop bits, fail to refresh random cells, cause programs to do crazy things by going into a refresh cycle at the wrong moment and all kinds of interesting things. Our poor customers will never have a chance to have these interesting experiences.

Even our documentation and software is no help. Not only do we have the most complete and thorough set of instructions available for any system, we are supplying software either free, or at crazy low prices. Our big documentation notebook for instance

is just full of information on the system. There are complete sections on software with sample programs and information on programming. We have no assembly instructions in that big yellow notebook. They are packed with the kits themselves. The notebook is completely devoted to instruction on using your computer system. You are therefore not going to be spending day after jolly day trying to find out how to put a program into your machine; researching all available outside literature in an attempt to discover just how you write software for the beast. Sorry about that folks, we didn't mean to spoil all your fun.

So please, have a heart, when you see those poor lonely souls that have purchased our systems say "hello". All they have to keep them interested in computers is writing and running programs. Our editor, assembler, 4K and 8K BASIC programs work so well that even this is quick and easy. So be kind to those poor bored SwTPC-6800 owners, it's not their fault that they have nothing to talk about.

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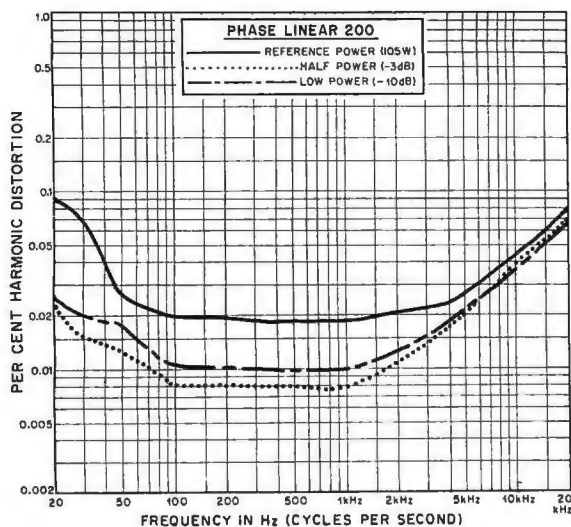
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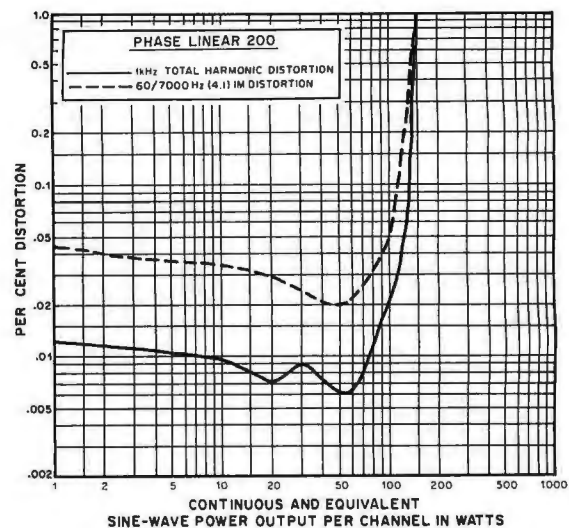
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Harmonic distortion vs frequency.



Distortion vs power output.

nel. There are no gain adjustments.

The low-level frequency response was flat from our measurement limit of 5 Hz to beyond 10,000 Hz, dropping to -0.9 dB at 100,000 Hz and to -3 dB at slightly beyond 200,000 Hz. The square-wave risetime was 1.5 μ s (rated at less than 1.7 μ s). Paralleling a 2- μ F capacitor across the 8-ohm load produced a single cycle of ringing on the square wave, at a frequency of about 50,000 Hz.

The peak power indicators came on rather gradually so that it was difficult to decide when a LED was on or off. In spite of this uncertainty, we found the LED's to be fairly accurate, with the PEAK indicator coming on at 109 watts and the others within 2 dB of their calibrated levels. The -10-dB switch actually increased the sensitivity of the display by about 5 dB.

The protective relay provided a time delay of several seconds when the amplifier was turned on before it connected the speaker systems to the outputs of the amplifier. It worked well on ordinary overloads, such as shorted speaker outputs, but when we attempted full-power operation at frequencies beyond 20,000 Hz, the line fuse blew before the relay acted. When we shut off the amplifier, the relay dis-

connected the speaker systems instantly, preventing any transient thumps from reaching them.

User Comment. In spite of its light weight and compact dimensions, this amplifier proved to be very powerful and conservatively rated. Its 140 and 160 watts of actual, as opposed to rated, output power over most of the audible range should be enough for most people, even when fairly inefficient speaker systems are connected to the amplifier.

The protective relay encouraged us to use the amplifier to drive some small bookshelf speaker systems that were rated at much less peak power than the amplifier can deliver. In use, the speaker systems were never subjected to excessive levels during any normal switching operation. (Phase Linear recommends, and we concur with, fusing the speaker system lines if the speakers are not rated to handle the full output power of the amplifier.)

The power-indicator LED's rarely glowed; even peak powers are not likely to exceed a few watts with such speaker systems at normal listening levels. However, their presence served as a constant reminder to prevent us from turning up the volume too far. We

always expected to see the center panel between the display indicators light up when we turned on the power; but in normal operation, there is no pilot light or other indication that the amplifier is "live." Obviously, we would like to see a power lamp installed behind the cutout window to provide some indication when power is turned on.

So far as we could tell, this amplifier was as free from any characteristic sound quality as the Phase Linear Model 400 amplifier, which we have used for some time. In fact, we doubt that one could distinguish between the two at any power level within the capability of the Model 200.

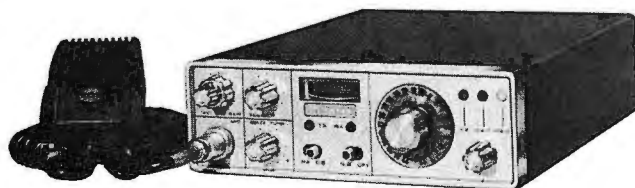
We experimented with the VELOCITY FEEDBACK switch. Except for a small change in gain, we could hear no difference when it was switched in and out of the system.

This amplifier permits the audiophile of modest means to enjoy the benefits of Phase Linear's justly deserved reputation for clean, undistorted, and powerful sound. With its matching companion Model 2000 preamplifier from Phase Linear, it makes an attractively styled high-quality amplifying sound system.

CIRCLE NO. 82 ON FREE INFORMATION CARD

PACE MODEL 145 AM CB TRANSCEIVER

Mobile rig features two extra channels for weather.



THE Pace Model 145 crystal-synthesized 23-channel CB transceiver offers two additional receiving channels for monitoring U.S. Weather Bureau broadcasts on 162.400 and 162.550 MHz. This mobile rig has all the usual features: Delta tuning, r-f and audio gain controls, squelch, S/r-f meter, automatic noise limiter (anl),

noise blanker (NB), PA operational mode, external-speaker jacks, and receive and transmit indicators. It is designed to operate from a nominal 12-volt dc, negative- or positive-ground, power source. Built into the dc power input circuit are reverse-polarity protection and a line filter.

The transceiver measures 10"D × 7½"W × 2¼"H (25.4 × 19.1 × 5.7 cm). It retails for \$239.95.

General Description. A double-conversion design is employed in the receiver section. One of six crystals in the 16.965-to-17.215-MHz range, depending on the CB channel to which the transceiver is tuned, is used to provide a first i-f of between 10.000 and 10.040 MHz. The second conversion is to a 455-kHz i-f, using one of four crystals in the 9.545-to-9.585-MHz range.

The diode-protected r-f stage is followed by two mixer stages. Then, i-f selectivity is obtained with a 455-kHz ceramic filter, which is followed by two i-f stages, the first of which is bandpass coupled. A voltage-doubling detector is followed by the audio anl circuit. The agc circuit is a voltage-doubling affair that also activates the squelch. The audio section ends up with the usual class-B power-output stage that doubles as the modulator for the transmitter.

The noise blanker picks up the impulse-noise pulses from the output of the first mixer and uses the pulses to gate the input of the i-f section by means of a diode switch.

The appropriate r-f and mixer circuits are provided for reception of the Weather Bureau broadcasts. The weather channels are labelled wx1 and wx2 and come equipped with 50.6166- and 50.5666-MHz crystals. These crystal frequencies are tripled for heterodyning to provide a first i-f of 10.7 MHz, which is then mixed with a 10.245-MHz crystal-controlled signal to produce a 455-kHz second i-f.

The signal is then set up for best clarity by operating the Delta-tune control to place the second i-f signal at the side of the ceramic filter curve that permits "slope" detection of the FM signal. The standard CB antenna is used for reception of the Weather Bureau broadcasts.

On transmit, the required 17-MHz synthesizer crystal signal is mixed with one of four crystal signals in the 10.000-to-10.040-MHz range to provide the on-channel carrier. Spurious

responses are minimized by bandpass circuits following the transmitter mixer. Buffer, driver, and power-output amplifier stages make up the rest of the transmitter section. The output circuit consists of a triple-section filter for matching to 50-ohm loads. Included in the filter section is a TVI trap.

Transmit/receive antenna change-over is performed electronically with a diode switch. Automatic modulation control (amc) takes over the gain of the audio section.

Test Results. Our measurements indicated a receive sensitivity of 0.5 µV (as rated) for 10 dB (S + N)/N when using a 1000-Hz test tone with 30% modulation. The maximum sine-wave audio output at the start of clipping was 3 watts at 10% THD, using the 1000-Hz tone and an 8-ohm load.

Unwanted spurious-signal rejection was a minimum of 50 dB, except in the area of 24 MHz, where it measured 30 dB. Image rejection was greater than 60 dB. Adjacent-channel rejection and desensitization were nominally 40 dB on the low and 60 dB on the high sides, which indicates the possibility of an asymmetrical shape of the ceramic filter's response or the response of the bandpass circuits. The overall 6-dB audio response was 350 to 3500 Hz.

The agc held the audio output to within 10-dB with a 20-dB r-f input change at 1 to 10 µV and to 14 dB with an 80-dB r-f variation at 1 to 10,000 µV. The S meter registered S9 with a nominal 100-µV r-f input signal. The range of the squelch control was from 0.35 to 400 µV.

We did not measure the sensitivity on the weather channels, but the manufacturer rates it at 2 µV for 20 dB (S + N)/N. This translates to less than 1 µV for a 10-dB ratio. During our listening tests, we obtained fine reception over a wide signal radius.

Operating the transceiver from a nominal 13.8-volt dc source, we measured a carrier output of 4 watts. Sine-wave modulation was available up to 100% with 7.5% THD. The amc had little control over preventing overmodulation, resulting in heavy squaring of both positive and negative peaks. Using a 1000-Hz test tone and raising the speech level by 10 dB above that required for 50% modulation slightly overmodulated the transmitter, with adjacent-channel splatter down 50 dB. Similarly, a 15-dB increase deteriorated the splatter figure to 40 dB down. Splatter with nor-

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mal voice operation was 45 to 50 dB down. The overall frequency response at the 6-dB points was 550 to 5000 Hz, and the r-f tolerance on any channel was within 0.002%.

User Comment. This transceiver is nicely styled in its black case accented by a brushed-aluminum front panel and chromed control knobs. Miniature toggle switches are used for switching between the PA and CB operational modes and for engaging and

disabling the noise blanker. (According to the schematic diagram, the anl is also simultaneously switched in when the noise blanker is engaged.) The effectiveness of the noise-suppressing circuits was slightly below what we have come to expect.

A separate control knob is used for selecting any of the 23 CB or two weather channels. Indicators identify which mode is in use. The frequencies for the wx1 and wx2 weather channels are listed at the rear of the manual that

accompanies the transceiver. In most cases, only one of these channels can be received in a given region.

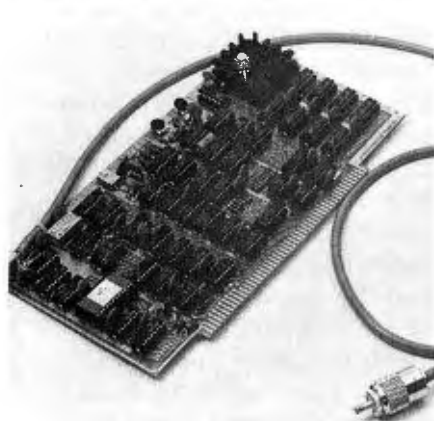
The S/r-f meter, which is illuminated edgewise, has blue scales on a black background. This can make it a bit difficult to interpret under most conditions. Although the 2½" (6.4-cm) oval speaker is bottom-facing, it puts out a hefty audio signal with an excellent response that makes for easy intelligibility and readability.

CIRCLE NO. 83 ON FREE INFORMATION CARD

PROCESSOR TECHNOLOGY MODEL VDM-1

VIDEO DISPLAY MODULE

Plugs into busline to provide 16 lines, 64 characters wide.



THE TYPE of computer busline used in the Altair 8800 and Imsai 8080 has become one of the most popular elements in the area of hobby type minicomputers. A number of devices have been designed to plug directly into this bus, a very useful one being the Processor Technology Model VDM-1 video display module, which occupies a single slot in the computer.

The video display module generates a page of text consisting of 16 lines by 64 characters wide. It provides the full 128 upper- and lower-case and control ASCII character set in a 7 × 9 dot matrix format and has an on-board memory system consisting of 1024 8-bit bytes of RAM. The two-port memory permits random read/write access to the screen from the CPU.

The VDM offers a choice of white-on-black or black-on-white switch-selectable for the entire screen or separately program controlled for each individual character; switch-selectable horizontal and vertical display position; switch-selectable text blanking for the CR control character to the end of the line or from the VT

character to the end of the screen; program control for scrolling in increments of one to 16 lines without rewriting memory; and "window-shade" blanking of the text above the desired starting location under program control.

The Model VDM-1 is available only in kit form through most computer stores for \$199.

General Information. The output of the video display module is a standard video signal. It couples directly to a video monitor or converted TV receiver via a coaxial cable that comes with the kit. (The assembly manual provides an extract from the Howard W. Sams book *TVT Cookbook* by Don Lancaster to illustrate some methods of converting TV receivers into video monitors.)

The assembled VDM can be installed and tested in an operating and running Altair-8800 or Imsai-8080 minicomputer without a language. All you need to get the system running is the computer and a video monitor. The manual illustrates some simple programs that can be fed into the

computer with front-panel switches to completely test the video display module and provide some familiarity with using it.

Processor Technology provides two types of software. The first is a machine language VDM driver that requires 512 bytes located anywhere but at the beginning of the computer's memory. (The company recommends the use of the last 512 bytes of the memory block.) All documentation is provided for this program. If you have BASIC, you use the BASIC-VDM driver tape. In this case, you also use the last 512 bytes of memory and run the tape. In essence, the BASIC program peeks and pokes around the language, determining the status and I/O values and patch points and loading the software into memory.

Once the driver software is loaded into the computer, everything thereafter is automatic. Following a brief pause, the system is coupled to the VDM. You then have a choice of output to either the VDM or the original input port for hard copy. To make your choice, you simply set switch A8 on the computer up or down.

One very interesting command that the VDM provides is "speed control." Simply by pressing any numeral key on the keyboard, you can control the speed of the program. Hitting the 1 key introduces no delay, and the characters on the screen whiz by at a rate of 2000 64-character lines/minute. As you proceed upward in numbers, the speed slows down until at 8, the characters move by at a rate of about 1.5/second. To stop the display at any time, you press the space bar. The space bar also lets you single-step through the program.

User Comment. The VDM is entirely assembled on a single, very large printed circuit board that has conductors on both sides and plated-through

holes. The top of the board is silk-screened to show component locations. Mounted on the board are 49 IC's, including the voltage regulator, plus a number of resistors and capacitors, two miniature potentiometers, a crystal, a couple of transistors and diodes, and a miniature DIP switch. The finished board, needless to say, is rather crowded.

Assembly itself is quite straightforward if you use a low-wattage soldering pencil or iron and fine wire solder. The manual is so well written and well illustrated that the VDM can be assembled and put into service in a single evening. The kit is complete, right down to the solder. The only things you need to put it together are a soldering iron, longnose pliers, and wire cutters.

The basic kit comes without IC sockets. However, Processor Technology offers an optional IC socket package that we decided to use with our VDM and highly recommend to anyone else who plans to build the video display module.

The board is wired according to a set sequence, as described in the manual. Initially, all parts except the IC's are mounted and soldered into place. Then, the IC's are installed in groups in a specific order. After the first group is installed, a test is performed. If the results of the test are correct as described in the manual, you go on to install the next set of IC's and perform the test for them, and so on until all IC's have been installed and tested. In this manner, if any problems develop, you can quickly pinpoint where they exist. If all IC's were installed before any tests were made and a problem cropped up, troubleshooting the VDM would be a frustrating, time-consuming procedure.

We have been using the Model VDM-1 for a couple of months and have had flawless operation from it during the whole time. Having used 32-character-wide terminals in the past, we always had to rewrite programs originally written for TTY to get them to run in our computer. Now that we have a 64-character-wide VDM, we do not have to go through the painstaking rewriting of programs.

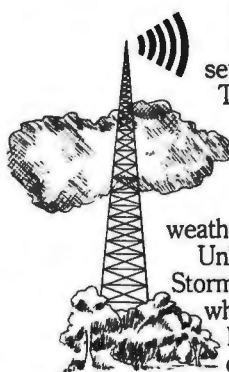
If you have a compatible operating computer system or are planning to buy one, we highly recommend a Model VDM-1 to use with it. For the performance it provides, the VDM-1 is very inexpensively priced.

CIRCLE NO. 84 ON FREE INFORMATION CARD

OCTOBER 1976

THE STORM ALARM.

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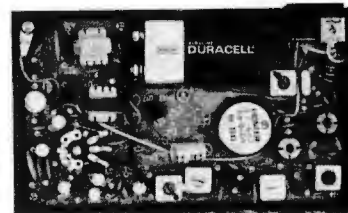
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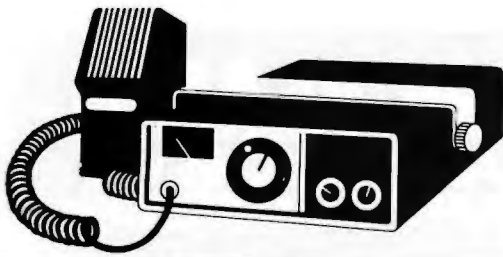
It's a foul and fair weather friend.



STORM ALARM

FROM WEATHERALERT

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CIRCLE NO. 78 ON FREE INFORMATION CARD



CB Scene

By Ray Newhall, KWI6010

THE LONG AND THE SHORT OF ANTENNAS

AN INEFFICIENT CB antenna system can easily waste more than half of the total power your transmitter pumps into it. Such losses could reduce your range by 50% and eliminate much of the punch you should get from your CB rig. To help you understand why, here are the most important antenna concepts described in plain language that doesn't require an engineering degree to understand. You should be able to use this information to improve your own antenna systems.

The maximum legal output power at a CB transceiver's antenna jack is four watts. Most modern transmitters actually produce an acceptable 3.5 to 3.9 watts when properly installed. It should be evident that all possible steps must be taken to minimize transmission line and antenna losses so that most of that power is transformed into the electro-magnetic radiation we call radio.

The antenna must be "tuned" to resonate at the proper frequency and the transmission line must be "matched" to the input impedance of the antenna. Otherwise, some of the power will be reflected back along the transmission line towards the transmitter and be dissipated as heat. In fact, if enough of the power is reflected, the transmitter may actually be damaged.

Standing Wave Ratio. The most common measure of antenna efficiency is expressed as a ratio of the power supplied to the antenna divided by the power reflected back to the transmitter. This measurement is called the Standing Wave Ratio (SWR). The Standing Wave Ratio of the perfect antenna system would be 1:1, but no antenna is perfect and any SWR of 2:1 or less is excellent. A ratio of 3:1 or less is acceptable. If the ratio is 10:1 or more, there is probably a short or an open circuit somewhere in the system, the antenna needs tuning or you are

not using the proper type of transmission line. Radio-frequency power is difficult to measure accurately and those meters that can separate the forward and reflected power and then measure them accurately are prohibitively expensive. But we get a fairly accurate *relative* indication of SWR by measuring either the voltage or the current at a particular point in the transmission line, and displaying the peak value on a low-cost dc microammeter. A reflectometer or SWR bridge is a low-cost meter which allows you to make such measurements readily. It should always be used when the antenna is installed, and again at intervals of six months or so. This will insure that your antenna continues to operate at top efficiency. The SWR bridge should be accepted for what it is, but many people place absolute faith in its readings. Most of these devices measure only the relative voltage peaks at the point in the line where they are inserted. When an r-f transmission line is mismatched and an SWR exists, the voltage and current in the line vary with line length. Accordingly, the SWR bridge can give different readings at different points along the line.

So when your CB buddy tells you that you can improve your SWR by installing a 12-foot transmission line, he is actually telling you how to improve your meter reading. But the actual SWR cannot be affected by changing the length of the coax. However, due to an entirely different effect, a transceiver will work better with some line lengths than with others if there is a high SWR on the line! In any event, both these conditions are symptoms of a mismatch.

To use the SWR bridge, its terminal marked "transmitter" should be connected to the transmitter's antenna terminal through a short piece of coax with the proper coax connectors on both ends. The "antenna" terminal on the bridge is connected to the trans-

mission line. With the "forward-reverse" switch in the FORWARD position, key the transmitter and adjust the SENSITIVITY control so the meter needle is at the full-scale position. Now switch the bridge to the REVERSE position and key the transmitter again. Most SWR bridges are calibrated to read SWR directly, but no matter—you should tune your antenna for the lowest possible REVERSE reading. The reading you get is only relative and probably does not represent an accurate SWR.

However, if the reading is much above 2:1, turn off the transmitter immediately before it is damaged. Disconnect the transmission line at both ends and use an ohmmeter to check it for continuity and for no shorts between the braid and inner conductor. If the line is OK, the problem is most likely in antenna tuning. Check the antenna and be certain it is properly installed. (Unless you really know what you are doing, you should always buy a commercial antenna.)

Take SWR readings at several different frequencies across the band. Determine, if possible, at which frequency it appears the lowest. If the SWR is at its lowest at one of the low channels (1 or 2), the antenna is too long and should be shortened. (Most mobile antennas have provision for adjusting the length somewhat.) If the lowest SWR appears at the highest channel number, the antenna is too short. The antenna should be tuned until the lowest SWR appears close to channel 13, the center of the Class D band.

If you have checked all connections and tuned the antenna carefully yet still cannot get the SWR less than 3:1, it is probable that you have failed to establish an effective ground plane for the antenna. Ground planes are discussed later on in this column.

Coax. Another problem sometimes encountered is in the transmission line you are using. The standard transmission line for CB radio is RG-58/U or RG-8/U (50 ohms impedance). Be careful not to use 75-ohm TV coaxial cable (RG-59/U) because it will not match accurately to the antenna. (There are exceptions to this rule; but in such a case, the manufacturer will provide the proper cable cut to the exact length required). If the transmission line can be less than 30 feet in length, then the smaller RG-58/U cable is probably adequate. But if the cable

must be longer than 30 feet, the larger RG-8/U (or equivalent) should be used to prevent excessive power losses.

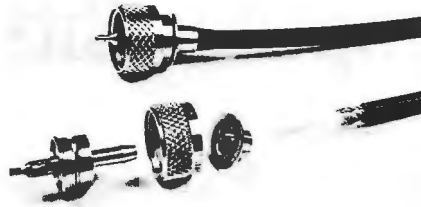
The transmission line should be as free as possible from splices, and care should be taken to avoid bruises and protect it from moisture. All splices and connectors should utilize uhf coaxial fittings of the PL-259/SO-239 type. The Amphenol Division of Bunker Ramo has recently announced a new solderless model of the PL-259 for RG-58/U, which they have named 83-58FCP. It gives a physically strong, electrically superior connection, in a fraction of the time required to assemble a soldered connector. It is about the same retail price as the commonly-used PL-259 (see photo). Only a pocket knife and a pair of pliers are required.

Ground Plane. By the time you have installed the proper type of CB antenna and tuned it as described above, you should have achieved an SWR of 2:1, or less. If not, the chances are that it doesn't have an adequate ground plane.

To understand the concept of the ground plane antenna, we'll have to discuss a little more antenna theory. The basic dimension for an antenna is one half of a wavelength, and wavelength is tied directly to the operating frequency. For the Class D Citizen's Band, the wave length is about 11 meters (36 feet). A half-wave vertical antenna extends 18 feet into the air, and is normally fed at the center point to form a "half-wave dipole."

But for most applications, an 18-foot antenna is unwieldy, especially for mobile applications. Fortunately, when mounted on a "ground plane," the antenna need only be half as long, with the missing quarter wavelength appearing as the *reflected electrical image* in the ground plane. At 27 MHz, a quarter-wave ground plane antenna has an electrical length of about 108 inches, but it may be shortened physically by incorporating a "loading coil" into its length. A ground plane antenna will also resonate at five-eighths of a wavelength and provide some power gain. Although 22 feet is usually too long to be practical for a mobile, it is used for some base stations.

The most effective ground plane is a flat conductive surface perpendicular to the axis of the antenna at its base, but isolated from it by a high impedance to r-f current. When the antenna



Amphenol FCP connector with RG-58U coax cable.

is fed by coaxial cable, the center conductor is connected to the antenna and the braid is connected to the ground plane. The ground plane should extend for at least a quarter wave-length in all directions from the antenna. In practice, a ground plane may be formed by three or four radial elements extending from the base of the antenna, or by the metal body of a vehicle. The radials used on base station antennas are often allowed to droop somewhat to provide a better impedance match to 50-ohm cable.

When the body of an automobile forms the ground plane, it is generally not large enough to extend nine feet in all directions, so the ground plane is not symmetrical. Under these circumstances, the radiation pattern of the antenna may be warped somewhat. The strongest signal will be radiated in the direction of the largest portion of the ground plane, and the signal will be diminished in the direction of the smallest portion. However, the total radiated power will remain constant except in extreme cases where the antenna is detuned and will not load properly. In short, the size and shape of the ground plane will have a major effect upon the symmetry of the horizontal radiation pattern.

The ground plane antenna is by far the most popular for use on CB because its dimensions make it useful for both base and mobile applications. However, on wood or fiberglass boats and campers it may not be possible to use a ground plane. For these applications, there are vertical half-wave dipole antennas available. These too may be physically shortened by use of loading coils. Such antennas are referred to as "marine" or "coaxial" antennas, and they cannot be used interchangeably with ground plane antennas.

All antennas discussed thus far have been of the "omni-directional" type. They can be used on CB without height restriction, except that they may not extend more than 60 feet

above the ground, natural formation, or man-made structure. Beam antennas can also be used on CB, but the height restrictions are more stringent. Any antenna which features distinct directional qualities may not be mounted more than 20 feet above ground, etc. Beam antennas are complex and may assume many forms including Yagis, Quads and phased arrays. The principles discussed above apply to all antennas. If you follow them carefully, you should be able to install an efficient antenna system, and keep it working efficiently. ♦

Stamp out



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Computer Bits

By Hal Chamberlain

COMPUTER MUSIC—PART II

LAST MONTH we discussed computer music techniques in general and simple timed-loop techniques specifically. Some short, illustrative programs for an 8080-based microcomputer were given. Also a circuit for a simple 8-bit digital-to-analog converter was shown. Now, we will delve a little deeper into computer music techniques that have the potential for producing complex, serious musical results.

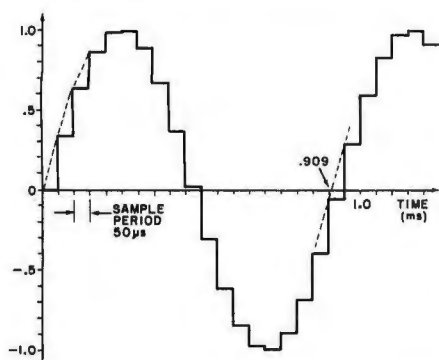


Fig. 1. Sampled sine wave.

The Sampling Theorem. Any waveform, no matter how simple or complex, can be represented as a series of discrete voltage values such as might come from a digital-to-analog converter (DAC). Figure 1 shows a sine wave as it might appear at the DAC output. This is termed a "sampled representation" because the sine-wave voltage is sampled at discrete points in time and held until the following sample point. Obviously this is a very poor sine wave, a fact that is easily demonstrated with a distortion analyzer.

Before giving up, let us look at the

frequency spectrum of this staircase-like wave on a spectrum analyzer. To be specific, the sine-wave frequency is approximately 1.1 kHz, corresponding to 0.909 milliseconds per cycle. The sampling frequency, often called sampling rate, is 20 kHz or one sample every 50 microseconds. The spectral plot shows a strong frequency component at 1.1 kHz, which is the desired sine wave we are trying to synthesize. Also shown are the distortion product frequencies caused by the sampling process. Since all of the distortion components are much higher in frequency than the desired signal, they may be attenuated or removed with a sharp low-pass filter. After filtering, the distortion analyzer will confirm that a smooth, pure, sine wave is all that remains.

What will happen if the sine-wave frequency is increased but the sampling frequency remains the same? With fewer samples on each sine-wave cycle, the waveform from the DAC will appear to be even more distorted. Close examination of the first pair of distortion components in Fig. 2 will reveal that they are very much like sidebands of a 20-kHz suppressed carrier "modulated" by a 1.1-kHz "signal." The lower sideband frequency is the carrier (20 kHz) minus the signal (1.1 kHz) or 18.9 kHz. The upper sideband frequency is the sum, or 21.1 kHz. There are also sideband pairs at harmonics of the sampling frequency. If the sine-wave frequency is increased, the lowest distortion component will move downward toward it, leaving less room for the low-pass filter to do its work. The limit oc-

curs when the desired frequency and the lowest distortion frequency actually meet each other at 10 kHz and can no longer be separated with the filter. The rule is that the highest frequency that can be reproduced with a sampled waveform is one-half of the sampling frequency. Actually achieving this requires an infinitely sharp filter; a more practical figure is $\frac{1}{4}$ or $\frac{1}{3}$.

Of course a real digital-to-analog converter cannot generate voltages that are exact samples of the sine wave. An 8-bit converter, for example, has only 256 possible output voltage values. When a particular voltage is needed, the nearest available value will have to be used. This "round-off" error gives rise to another type of distortion in sampled waveforms called *quantization noise* which is spread throughout the frequency spectrum. The theoretical signal-to-quantization noise ratio is easily computed as $6N+4$ dB, where N is the number of bits in the DAC. Actually this assumes an ideal DAC; a realistic figure is about 5 dB less. Still, an 8-bit DAC yields nearly 50 dB, as good as many tape recorders. With a 12-bit DAC, the quantization noise is negligible.

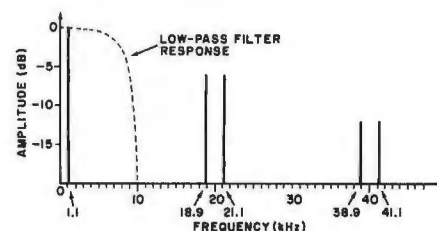


Fig. 2. Spectrum of Fig. 1.

Waveforms From Tables. With this background, it is apparent that a sampled representation of a waveform may be stored in the memory of a computer. A simple way to do this is to store one cycle of the waveform in a small block of memory as a "table." Now the waveform can be reproduced by having a program scan through the table in memory and send the samples to a DAC. The frequency of the waveform is a function of the sample rate (time between sending out successive samples) and the number of points tabu-

FIG. 3

```
*
* TOUCH-TONE TRANSMIT SUBROUTINE
* ENTER WITH DIGIT TO SEND IN A, 4 BIT BINARY CODED DECIMAL
* EXITS WITH ALL REGISTERS DESTROYED
* ASSUMES 2 MHZ CLOCK AND NO MEMORY WAITS
* SENDS TONES FOR 200 MILLISECONDS, SILENCE FOR 100 MS
```

```
000:200
000:200 346 017
```

```
ORG 200Q
TTXMIT ANI 017Q MASK OFF EXCESS BITS IN A
(Subroutine continued on page 91)
```

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lated for one cycle. If the sample rate is varied, care must be taken to prevent it from becoming too low.

A better way is to alter the apparent table length by scanning every second, third, etc. entry during the output process. This restricts us to a few specific frequencies. Any frequency may be generated by allowing "fractional" scan increments. When fetching a table entry, the nearest one would be used but the fractional part would be retained when computing the location of the next table entry. A prime advantage of waveform tables is that the tone color can be changed simply by using a different table.

Mixing Computed Waveforms. If a computer is to play interesting music with chords, counterpoint, etc., then two or more simultaneous tones will be required. One approach is to use multiple DAC's and an audio mixer along with a program to constantly feed sample values to each DAC from tables in memory. The same effect can be achieved with one DAC if at each sample time the current sample values for all tones are added together and the sum sent to the DAC. Of course the sample rates of all of the tones must be the same. Even relative loudness can be controlled by multiplying a tone's sample value by a "loudness factor" before it is added to the total. Attack and decay envelopes can be simulated by constantly changing the loudness factor. Care must be taken to avoid arithmetic overflows, however. Typically, the intermediate arithmetic is done to 16 or more bits of accuracy and the final result is rounded off to the number of bits used by the DAC.

Touch-Tone Program. Many of the concepts just discussed are illustrated by the Touch-Tone[®] transmit subroutine in fig. 3. A Touch-Tone digit consists of two simultaneous sine-wave tones, one from a low-frequency group (697, 770, 852, 941 Hz) and one from a high-frequency group (1209, 1336, 1477, 1633 Hz). The routine actually synthesizes the two tones already mixed together through an output port equipped with the simple DAC mentioned earlier.

The routine is called with register A containing the digit to be transmitted in binary. Using the binary code, the routine accesses a frequency table to determine what the "table increment" value for each tone should be. For example if a "4" is to be sent, every

tenth sine-table entry would be used for the 770-Hz tone and every fifteenth for the 1209-Hz tone. Note that this gives only approximate frequencies; the 1209-Hz tone is off 3%, but the others are off less than 1.5%.

For the actual tone-generation task, the routine maintains two sine-table pointers, one for each tone. To compute a mixed-tone sample, the sine-table entry pointed to by each pointer is fetched, they are added together, and the sum is divided by 2 to produce an 8-bit result. For the next sample, the corresponding increment is added to each pointer. Overflow of the lower pointer byte is ignored to provide for "wrap-around" to the beginning of the sine table when a cycle is completed. The loop for computing samples is 100 machine cycles long, which gives a 20-kHz sample rate assuming a full-speed 8080 system. With this fairly high sample rate, low-pass filtering can be accomplished with tone controls or a scratch filter.

The routine can be expanded for more simultaneous tones if desired or a different waveform can be entered into the table. There is a definite limit to the computation between samples, otherwise the sample rate may fall too low to be useful. Also, the loop times have to be carefully controlled.

Mass Storage And Playback. In music programs for large computers, the computed waveform samples are not sent directly to a digital-to-analog converter. Instead they are saved on a mass-storage device and "played back" later. The advantage of this approach is that time is not a factor when the samples are computed. The calculations may be as complex as necessary or a high-level language can be used with no effect on the sample rate during playback. This method has perfect generality; any possible sound or combination of sounds can be synthesized, subject only to frequency-response limitations imposed by the playback sample rate.

The problem for hobbyists of course is standing the expense of a suitable high-speed, large-capacity mass-storage device. Interesting experiments can be performed however with systems having 16k or more of memory. At a 10-kHz sample rate, which gives AM radio quality, a 24k machine can hold over 2 seconds of sound. For the industrious, two-second segments can be recorded on audio tape and spliced together for the final result. ♦

000:202	041	271	000	LXI	H,TTTABL	GET ADDRESS OF FREQUENCY TABLE
000:205	207			ADD	A	DOUBLE CONTENTS OF A
000:206	205			ADD	L	ADD RESULT TO TABLE ADDRESS
000:207	157			MOV	L,A	MOVE FIRST TABLE ENTRY
000:210	176			MOV	A,M	TO TONE A INCREMENT
000:211	062	331	000	STA	TONAIN	
000:214	043			INX	H	MOVE SECOND TABLE ENTRY
000:215	176			MOV	A,M	TO TONE B INCREMENT
000:216	062	332	000	STA	TONBIN	
000:221	001	240	017	LXI	B,7640Q	SET COUNT FOR 200 MILLISECONDS IN BC
000:224	021	000	001	LXI	D,SINET	SET DE TO POINT TO SINE TABLE
000:227	041	000	001	LXI	H,SINET	SET HL TO POINT TO SINE TABLE
000:232	032			LDAX	D	GET TONE A SAMPLE FROM SINE TABLE
000:233	206			ADD	M	ADD TO IT TONE B SAMPLE
000:234	037			RAR		DIVIDE SUM BY 2
000:235	323	XXX		OUT	(port address)	SEND TO OUTPUT PORT WITH 8 BIT DAC
000:237	072	331	000	LDA	TONAIN	GET TONE A INCREMENT
000:242	203			ADD	E	ADD TO IT TONE A SINE TABLE POINTER
000:243	137			MOV	E,A	UPDATE TONE A POINTER
000:244	072	332	000	LDA	TONBIN	GET TONE B INCREMENT
000:247	205			ADD	L	ADD TO IT TONE B SINE TABLE POINTER
000:250	157			MOV	L,A	UPDATE TONE B POINTER
000:251	013			DCX	B	DECREMENT AND CHECK TONE DURATION COUNT
000:252	170			MOV	A,B	
000:253	261			ORA	C	
000:254	302	232	000	JNZ	TONES	LOOP FOR ADDITIONAL SAMPLES UNTIL DONE
000:257	001	100	037	LXI	B,17500Q	SET COUNT FOR 100 MILLISECONDS OF SILENCE
000:262	013			DCX	B	DECREMENT AND CHECK SILENCE DURATION COUNT
000:263	170			MOV	A,B	
000:264	261			ORA	C	
000:265	302	262	000	JNZ	SILENC	LOOP UNTIL COUNT RUNS OUT
000:270	311			RET		RETURN

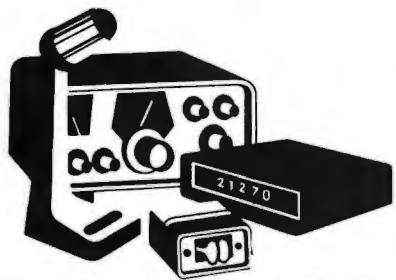
* TOUCH-TONE FREQUENCY TABLE, TWO VALUES PER ENTRY

000:271	014	021	TTTABL	DEF	12,17	0	941	1336
000:273	011	017		DEF	9,15	1	697	1209
000:275	011	021		DEF	9,17	2	697	1336
000:277	011	023		DEF	9,19	3	697	1477
000:301	012	017		DEF	10,15	4	770	1209
000:303	012	021		DEF	10,17	5	770	1336
000:305	012	023		DEF	10,19	6	770	1477
000:307	013	017		DEF	11,15	7	852	1209
000:311	013	021		DEF	11,17	8	852	1336
000:313	013	023		DEF	11,19	9	852	1477
000:315	011	025		DEF	9,21	A	697	1633
000:317	012	025		DEF	10,21	B	770	1633
000:321	013	025		DEF	11,21	C	852	1633
000:323	014	025		DEF	12,21	D	941	1633
000:325	014	017		DEF	12,15	*	941	1209
000:327	014	023		DEF	12,19	#	941	1477

000:331	TONAIN	DST	1	STORAGE FOR TONE A INCREMENT
000:332	TONBIN	DST	1	STORAGE FOR TONE B INCREMENT

* SINE TABLE FOR USE WITH TOUCH TONE SUBROUTINE
 * MUST BE AT A PAGE BOUNDARY
 * LISTED IN MEMORY DUMP FORMAT TO CONSERVE SPACE

001:000	200	203	206	211	214	217	222	226	231	234	237	242	245	250	253	256
001:020	261	263	266	271	274	277	301	304	307	311	314	316	321	323	326	330
001:040	332	334	336	341	343	345	346	350	352	354	355	357	361	362	363	365
001:060	366	367	370	371	372	373	374	375	375	376	376	377	377	377	377	377
001:100	377	377	377	377	377	377	376	376	375	375	374	373	372	371	370	367
001:120	366	365	363	362	361	357	355	354	352	350	346	345	343	341	336	334
001:140	332	330	326	323	321	316	314	311	307	304	301	277	274	271	266	263
001:160	261	256	253	250	245	242	237	234	231	226	222	217	214	211	206	203
001:200	200	175	172	167	164	161	156	152	147	144	141	136	133	130	125	122
001:220	117	115	112	107	104	101	077	074	071	067	064	062	057	055	052	050
001:240	046	044	042	037	035	033	032	030	026	024	023	021	017	016	015	013
001:260	012	011	010	007	006	005	004	003	003	002	002	001	001	001	001	001
001:300	001	001	001	001	001	001	002	002	003	003	004	005	006	007	010	011
001:320	012	013	015	016	017	021	023	024	026	030	032	033	035	037	042	044
001:340	046	050	052	055	057	062	064	067	071	074	077	101	104	107	112	115
001:360	117	122	125	130	133	136	141	144	147	152	156	161	164	167	172	175



Amateur Radio

By Herbert S. Brier

250 WATTS FOR NOVICES

EFFECTIVE July 23, 1976, the FCC raised the permissible dc power input limit for Novices from 75 to 250 watts. The Commission also set the same power limit for all other amateurs using Novice frequencies. In the same notice, Technicians received Novice hf privileges. Also, the Technician and Conditional Class licenses issued by mail became equivalent in all respects to Technician and General Class licenses, respectively, earned before an FCC examiner.

Since that date, the only amateur license issued by mail is the Novice Class, with one exception. If an applicant is disabled, and that disability is confirmed by a doctor's certificate, examinations can be conducted in the home under the supervision of a volunteer examiner selected by the Commission.

Two other changes affect Novices. The one-year wait between the expiration date of a previous amateur license and a Novice ticket has been eliminated. Now, by proper timing, a Novice whose license will expire can be retested before his current term runs out. In addition, the Novice exam contains material not covered in any other amateur examination. Therefore, all higher class tests will include the Novice exam. To prevent applicants who want Novices in a hurry from trying to get the ticket at an FCC office, the Novice questions will be graded only after the other elements have been passed.

Equipment. The eyes of many Novice and Technician operators probably gleam as they imagine how much stronger their signals will be with 250 watts of input power in place of 75 watts. But the change will not be as dramatic as they might hope. This increase is equivalent to 5.2 dB. If the fellow you're working has an S meter that moves one S unit for a 6-dB increase in signal strength, switching from the old power limit to the new one will boost your signal just under one S unit—a useful, but hardly spectacular, change. (However, very few of us have S meters that follow this "textbook" behavior!)

The most important benefit that Novices receive from this change is a wider selection of equipment suitable for Novice use. In the 75-watt category, the only transmitters that can be purchased *new* are the Heath DX-60B and the HW-16. The DX-60B has a maximum input power of 90 watts, covers 80 through 10 meters in the CW and AM (screen modulation) modes. The HW-16 transceiver covers the CW portions of the 80-, 40-, and 15-meter bands. Both are in kit form, and have given many amateurs valuable experience in building and operating them. But most amateurs who have "cut their teeth" using the rigs have sold them upon receipt of the General or Advanced Class

license, and applied the proceeds to the purchase of a CW/SSB transmitter or transceiver. So, although they were ideal "starter" rigs, these units were not long-term investments.

Under the amended rules, a Novice can now acquire one of the many transmitters or transceivers in the 180-to-250-watt class not only for use under his current license, but for General and higher class operation as well. These rigs work excellently on CW, most with partial or full break-in. Plugging a mike into them makes operation on SSB phone possible, and many will also work on RTTY and slow-scan TV with the addition of accessory equipment.

Standard amateur gear in transceiver or "separate" form covers 80 through 10 meters. A few also offer 160 meters. Transceivers use many stages which perform two different functions. (For example, a buffer amplifier during transmit can be an i-f amplifier on receive.) Their advantages are economy, compactness, and ease of operation. However, they can transmit and receive only on the same frequency, unless the transceiver has "receiver incremental tuning" or can accommodate an external vfo. Receiver incremental tuning allows the receive frequency to be shifted up or down a few kilohertz without affecting the transmit frequency. External vfo's allow you to transmit at one end of the band and receive at the other.

Most often, amateurs on the hf bands transmit and receive on the same frequency. But some DX stations won't listen on their own frequency, directing stations to call "10 kHz up" or so. Also, some DX SSB stations transmit in the "foreign phone" bands, such as 14.1 to 14.2 MHz. U.S. amateurs wishing to talk to them must transmit somewhere above 14.2 MHz and listen below that frequency. So, if you plan to chase a lot of DX, you should get either a separate transmitter and receiver or a transceiver that can accept a remote vfo.

"Separates" are more expensive than transceivers, require more room, and are more versatile. Because they can be individually adjusted for optimum performance, separates operate somewhat more efficiently, especially on receive. Exact comparisons on a cost-vs-performance basis are difficult, however. A compromise between transceivers and separates are "matched" transmitters and receivers. They can be operated in the transceive or independent mode at the flick of a switch.

Oddly enough, most matched transmitters have lower power output levels than transceivers—150 to 200 watts compared to up to 500 watts PEP, respectively. The first SSB transceivers were designed for mobile operation, and TV sweep tubes were put in them to get high peak power in a small package. Such tubes work well, but their distortion

products are somewhat higher than those from tubes specifically designed for hf SSB transmitting. As a result, most separates and some transceivers accept one to three dB less output power in return for measurably lower distortion, and use 6146B tubes. But even those rigs with 180 watts of input power (about 100 watts out) can drive 2000-watt, grounded-grid linears. So don't let their "low" power levels fool you. They can be operated barefoot for most contacts, and be switched over to drive a linear if conditions get really bad.

High-power r-f transistors are still very rare, and those solid-state transceivers currently on the market are limited to about 200 watts of input power. Most transmitters are either hybrid (solid-state oscillators, etc. with tube drivers and finals) or all-tube designs. Many transceivers are hybrids. However, many new receivers use no vacuum tubes, and this is the trend of the future for *all* amateur gear.

More important than the number of tubes or transistors that a piece of equipment has are its key specifications. For example, a receiver should have a sensitivity of less than 1 μ V at 10 dB S+N/N, an SSB selectivity of 2.1 to 2.5 kHz, and a CW selectivity of less than 500 Hz at the 6-dB points. A transceiver or transmitter should have 150 to 400 watts of input power on CW. A transceiver should be able to operate from 12 volts dc or 117 volts ac.

You should also consider how flexible a rig is before you buy it. For example, if you want to work vhf, does that receiver accept plug-in converters? Or, will that transceiver interface easily with a transverter, speech processor, or monitor scope? Get as much information as possible about each rig you are considering before making any decisions. The following manufacturers will supply specific information about their equipment upon request:

Atlas Radio, Inc.,

317 Via del Monte
Oceanside, CA 92054

Collins Radio Group,

Amateur Radio Marketing,
Rockwell International
Cedar Rapids, IA 52406

R.L. Drake Co.,

Miamisburg, OH 45342

Heath-Schlumberger,

Benton Harbor, MI 49022

Trio-Kenwood Communications, Inc.

116 East Alondra,
Gardena, CA 70248

Swan Electronics,

Div. of Cubic Corp.,
305 Airport Road,
Oceanside, CA 93054

Tempo

c/o Henry Radio Co.,
11240 Olympic Blvd.,
Los Angeles, CA 90064

Ten-Tec, Inc.,

Sevierville, TN 37862

Yaesu Musen USA, Inc.,

7625 E. Rosecrans, No. 29,
Paramount, CA 90723.

I hope that I have not omitted any company currently manufacturing CW/SSB equipment for the hf amateur bands.

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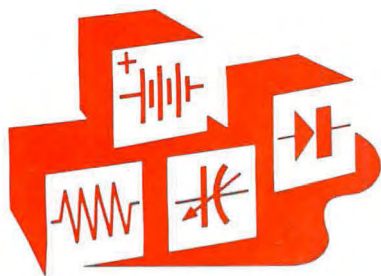
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Inside Basic Electronics

By Sol D. Prensky

CAPACITORS AND RC CIRCUITS

CAPACITORS are so important in the realm of electronics that you'd be hard pressed to find a circuit that doesn't employ at least one of them. Often, the capacitor is teamed with a resistor. This *RC* combination plays a dominant role in shaping the network's overall *frequency response*. For a clear understanding of *RC* circuits, we'll first take a close look at the capacitor, and then see how it behaves when paired with a resistor.

Fundamentals of Capacitors.

Every capacitor consists of two conductive plates separated by an insulating medium called a *dielectric* (Fig. 1). When a dc voltage is applied across the capacitor (by closing the switch), electrons start flowing from the negative terminal of the battery onto the bottom plate of the capacitor. Simultaneously, the battery's positive terminal attracts electrons from the top plate. At first, the electrons flow fairly easily. But as more and more of them are piled up on the bottom plate, it becomes increasingly harder for any more electrons to join them.

Here's why. Electrons are all negatively charged, and like charges tend to repel each other. Eventually this repulsive force will counteract the force generated by the battery which causes electrons to move, and no more current will flow. (When we talk of "current," we refer to *conventional* current, which flows in the opposite direction to the motion of electrons.) The voltage across the capacitor will equal that across the battery. Furthermore, the bottom plate will have a surplus of electrons and will be negatively charged. The top plate will have a deficiency of electrons and will be positively charged.

We can find out just how much charge the capacitor is holding by using the simple equation $Q = CV$. This means that the charge in *coulombs* (one coulomb = 6.281 billion

million electrons!) is equal to the applied voltage times the capacitance in *farads*. (The farad, which is the basic unit of capacitance, is so named to honor the British scientist Michael Faraday.) Thus we see that the capacitance of a capacitor is a measure of how much charge it can hold. And this presents the key to understanding the capacitor—it is an *energy storing* device. If we open the switch in Fig. 1, the voltage across the capacitor remains the same. No current will flow through the dielectric to *discharge* the capacitor if the dielectric is a good insulator. So, the charges are trapped on the metal plates. We could attach a light bulb (or any other load) across the capacitor and it would behave like a battery until enough current flowed from one plate to the other to compensate for the charge unbalance. At that point, the voltage across the capacitor would be zero, because its charge would have been depleted.

Among the factors that determine capacitance are the area of each plate, the spacing between the plates, and a quantity called the *dielectric constant*. If the plates are made larger (increased area), the capacitance will rise. When the plates are moved further apart, capacitance decreases. If an insulating medium with a dielectric constant of 1 (air) is replaced with one having a constant of 2 (paper), capacitance will be doubled.

In electronic applications, the farad is much too large a unit of capacitance. The more common units are microfarads (μF or 10^{-6} F) and picofarads (pF or 10^{-12} F). Another

quantity of interest is the *leakage resistance*. We noted before that a charged capacitor will hold its stored charge until a load is placed across it. But that represents an idealized situation. No dielectric is a perfect insulator, but can be represented as a resistor in parallel with the capacitor. This leakage resistance allows a leakage current to flow through it which tends to discharge the capacitor. In most cases, we want this resistance to be as high as possible—on the order of many megohms—to make the capacitor a good storage place of electric charge.

DC and AC Behavior. If we apply a dc voltage across a capacitor, we note a transient charging current which stops as soon as the capacitor has fully charged. In other words, once the capacitor has charged, it acts like an open circuit for dc signals, and will block them. But the capacitor behaves differently in ac circuits. Without getting into details, suffice it to say that a capacitor displays *reactance*, which is an opposition to the flow of ac. Although reactance is measured in ohms, it is not a true resistance. A reactance does not consume any power by converting it into heat, as a resistance does, but rather returns power to the source of the ac signal. Capacitive reactance varies inversely with frequency and capacitance. That is, when capacitance is increased, reactance decreases, and if frequency is increased, the reactance grows smaller. The formula for capacitive reactance is $X_c = 1/(2\pi fC)$, where X_c is measured in ohms, f in hertz, and C in farads. Using this formula, we find that a 1- μF capacitor has 160 ohms of reactance at 1000 Hz, and 16 ohms at 10,000 Hz.

One example of capacitive behavior is in blocking and coupling, which is one of the most common ways in which a capacitor is used. Tubes and transistors can amplify ac signals, but to work properly, certain dc voltages must be applied to them. The plate of a tube can be set at a dc level of several hundred volts in a high-power

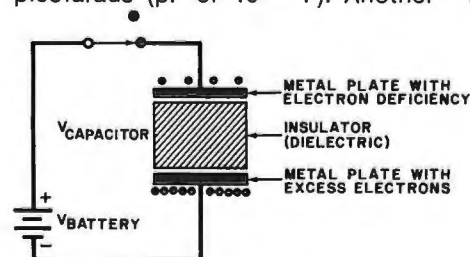


Fig. 1. The capacitor is basically a charge storing device.

amplifier. But we must take the ac output at this point without disturbing the dc level. So, we install a coupling capacitor at the plate. It acts as an open circuit to dc, but allows the ac signal to pass through it.

Of course, the capacitor must be chosen so that its reactance is low for the signal frequency, and its leakage resistance is high enough not to disturb the dc operation of the tube, as well as to prevent appreciable dc from flowing into the next stage or the load. Finally, we must choose a capacitor that can withstand the highest dc voltage that would exist across it. That is, it must have a sufficient *working voltage* rating. If this voltage is exceeded, the dc can arc over—as it does in a spark plug—with disastrous consequences.

Capacitor Types. Now that we know how a capacitor basically works, let's take a look at the various packages they are put in, and what materials are used to make them.

There are two major classes of capacitors: *polarized* (electrolytic) and *nonpolarized* types. The main factor that determines in which class or sub-class a capacitor falls is the dielectric material used. Nonpolarized capacitors can be inserted into a circuit without regard for which plate is positively charged, or which is negatively charged. Polarized capacitors are marked with one plate positive and the other negative. They must be inserted so that the positive plate is always at a higher potential (referenced to ground) than the negative plate.

Without delving too deeply into the peculiarities of each type, we can summarize the characteristics of nonpolarized capacitors as follows:

- *Paper dielectric* capacitors are the least expensive type to make. They cannot be used at frequencies much above 1 MHz, and are found primarily in audio circuits.

- *Organic film* types, such as polyester, Mylar, polystyrene, and polycarbonate capacitors, are intermediate in cost, offer large leakage resistance (10^{10} to 10^{14} ohms), and greater capacitance per unit volume than paper components. These dielectrics can also be used at higher frequencies than paper capacitors.

- *Ceramic dielectric* capacitors are widely used because they are fairly inexpensive, can be used in audio as well as r-f circuits (up to tens of MHz),

and are available in capacitances from 1 pF to 1 μ F, with working voltages up to several thousand volts. Leakage resistance is high, and they are marked for specific temperature coefficient information from *P* (positive, meaning increased temperature raises capacitance), to *N* for negative, in parts per million per degrees centigrade (ppm/°C). The designation *NPO* means negative-positive zero coefficient (virtually no change in capacitance over the -25°C to $+85^{\circ}\text{C}$ range).

- *Mica* or *silver mica* types offer excellent response into the vhf re-

gion, high leakage resistance, and tight tolerance (as low as $\pm 1\%$, as opposed to $\pm 10\%$ or $\pm 20\%$ for other nonpolar capacitors). Working voltages can be made very high—on the order of several kilovolts. They are more expensive than ceramic capacitors, but are often used in precision and r-f applications, where increased cost is justified by superior performance.

- *Glass* is a dielectric that is superior to mica in many ways. *Glass capacitors* can be made to very close tolerances, and have excellent fre-

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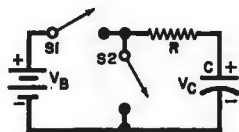


Fig. 2. Simple RC circuit.

quency response and leakage characteristics. They are also rather expensive.

The major limitation of all these nonpolarized capacitors is the amount of capacitance that can be packed into a container of reasonable volume. Up to about a tenth of a microfarad or so, packages are fairly small. But they become unwieldy as 1 μF is approached. For really large capacitances in small cans, we must use polarized or *electrolytic* capacitors.

These devices consist of two metallic electrodes separated by an *electrolyte* (hence their name). When a voltage is impressed across the electrodes, a thin film of nonconducting oxide is produced by chemical (electrolytic) action to form the dielectric. The rest of the electrolyte conducts fairly well, so the two electrodes are effectively separated only by the thin

oxide layer. As we noted earlier, closely spaced plates mean high capacitance, and this is why the electrolytic capacitor has such high capacitance ratings. However, extreme care must be taken to insure that the proper polarizing voltage is applied, because reverse or excessive forward voltages can irreparably damage the capacitor.

The two most common types of electrolytic capacitors are *aluminum* and *tantalum*. They consist of either a foil (aluminum or tantalum) or a dry slug (tantalum). Foil units contain a liquid or gel electrolyte between the foil anode and the case that is in continuous contact with the oxide layer, and that participates in its formation. Slug-type capacitors employ a solid semiconducting electrolyte, and the anode is a sponge-like porous metal slug. In dry tantalum capacitors, manganese dioxide is commonly used as the electrolyte.

Dc leakage is an important factor in electrolytic capacitors. Some of them are quite leaky. Although this is tolerable in certain applications, it is most undesirable in others.

Tantalum capacitors generally display less leakage than aluminum

components, and are often used because of this. Also, tantalums can be made to $\pm 20\%$ or even $\pm 10\%$ tolerances. Aluminum capacitors often have a $+100\%$, -50% tolerance, which can rule out their use in certain circuits. Finally, aluminum electrolytics are frequency limited. They are useful up to 50 kHz at most, so are found mainly as filters in power supplies and as coupling or bypass capacitors (passing ac signals to the next stage or shunting them to ground) in audio circuits.

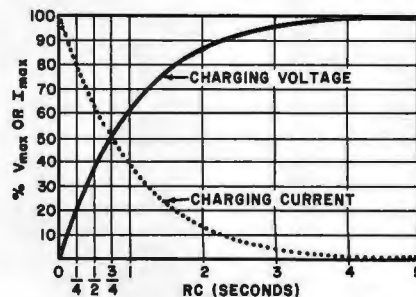


Fig. 3. Universal curves of charging voltage and current versus time. Computer-grade electrolytics are found in power supplies because they can store large amounts of energy. You can find aluminum and computer grade capacitors rated at up to 10,000

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μF or more and several hundred working volts, but today the high-voltage components are getting rare because solid-state circuits don't require the dc voltage levels that tubes do. Tantalum capacitors have ratings of a fraction of a microfarad up to 700 μF or so. Their voltage ratings generally lie between 3 and 50 volts.

Variable Capacitors. So far we have talked only about fixed capacitors. That is, those capacitors whose capacitance is set in the manufacturing process. But *variable* capacitors are also very important. Every tuning-dial radio has at least one. The most common type of variable capacitor uses air as the dielectric, and has two sets of interleaved

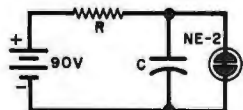


Fig. 4. Basic relaxation oscillator.

plates. One set, called the stator, is bolted to the frame of the capacitor. The other set, the rotor, is attached to a shaft that allows the two sets to be meshed (maximum capacitance), or

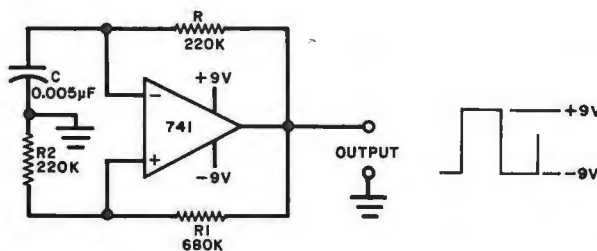


Fig. 5. Oscillator using an op amp as comparator produces high-amplitude square waves.

fully unmeshed (minimum capacitance), or anything in between. The capacitor is described by these two values, as well as its air gap (spacing between plates) and maximum working voltage. The latter two specifications are important in transmitting applications, where high-voltage r-f is present. In fact, sealed vacuum capacitors are available for high-power operation.

Other types of variable capacitors are *trimmers* and *padders*. They are used to fine-tune a network, and usu-

ally have screwdriver adjustments. They can have air, mica, plastic, or quartz dielectrics, and can take the appearance of a small piston and cylinder, a small box, or two plates (one above the other) on a ceramic body.

All variable capacitors are noted for their small capacitance values. The typical tuning capacitor in an AM radio is rated at 365 pF maximum. Trimmer and subminiature tuning capacitors can have *maximum* capacitances of less than 10 pF! Remember, though, that capacitance isn't everything, and



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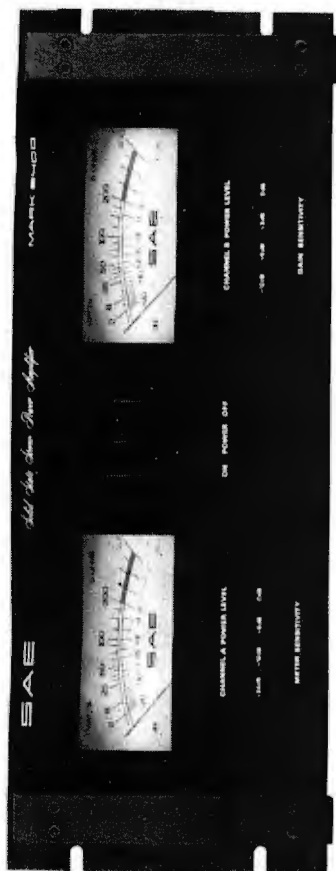
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variable capacitors are indispensable in most communications equipment.

Combining R and C. When a resistor and capacitor are connected together, several interesting things happen. First, the relative magnitudes of R and C affect how quickly the capacitor will charge up. Second, the combination can act as a filter, passing high or low frequencies, depending on how the RC pair is connected across a signal source. Let's look at the dc charging action first.

The product of R in ohms and C in farads is called the RC time constant, and is symbolized by the greek letter tau (τ) and expressed in seconds or microseconds (μs). The time constant appears in many descriptions of the frequency response of oscillator and filter circuits, and is also important to the action of many pulse circuits. It is most easily understood as the factor that determines how fast a capacitor can charge through an effective resistance. From here we can determine the time T or period required for one complete cycle of oscillation, and thus the frequency.

If we were to close switch $S1$ of the circuit in Fig. 2, and monitor the voltage across the capacitor with a voltmeter or oscilloscope, we would see that the voltage starts to build up rather quickly, but then the rate of increase drops off. Graphing the voltage against time or taking a snapshot of the scope trace would yield the solid-line curve shown in Fig. 3. It is an exponential curve that is universal in terms of the RC time constant.

We call the curve an exponential one because we can express the voltage across the capacitor by the equation $V_C = V_B (1 - e^{-t/\tau})$, where V_C is the voltage across the capacitor, V_B is the battery voltage, t is the time in seconds after the switch is closed, e is the base of natural logarithms (approximately 2.718), and τ is the time constant in seconds. The equation tells us that at $t = \text{zero seconds}$ (as the switch is closed), the voltage across the capacitor is zero. After the number of seconds equal to one time constant, $V_C = V_B (1 - e^{-1})$, or $V_C = V_B (1 - 1/2.718)$. Solving this equation, we get $V_C = 0.63 V_B$, or, after one time constant, the voltage across the capacitor has reached 63% of the battery voltage.

After one time constant, the capacitor charges more slowly. We can see from the graph that after two

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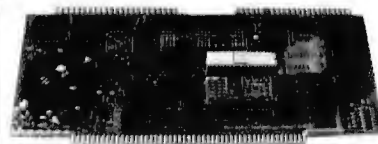
time constants the capacitor voltage is about 86% of the battery voltage, increasing to about 98% after four time constants. Theoretically, it would take the capacitor an infinite amount of time to charge to the full battery voltage; but, as a practical matter, we will consider the capacitor to be fully charged after 5 time constants have passed. Unlike voltage, charging *current* decreases with time. It is shown as the dotted curve in Fig. 3, and essentially is a mirror image of the voltage curve. We can see that charging current never stops (it would take an infinite time to do so), but after 5 time constants it is less than 1% of its initial turn-on value.

In the theoretical case shown in Fig. 1, the capacitor will hold its charge forever after it is disconnected from the voltage source, if its leakage resistance is infinite. Although this is never the case in practical components, good capacitors will hold most of their charge for a reasonably long time. (That's why it's dangerous to handle line powered electronic equipment *after power has been removed* if you haven't discharged the filter capacitors with a shorting stick.) But what happens if we allow capacitor *C* to discharge through *R*? We can do this by opening *S1* in Fig. 2 and then closing *S2*—which has been open up to this point.

If we use our oscilloscope or voltmeter to monitor the voltage across the capacitor, we'll see that it decreases exactly the same way as the charging current did. That is, after one time constant the voltage will have decreased to 37% of its open circuit value. As more time passes, the capacitor discharges more slowly. After two time constants, voltage is down to 14%; after three time constants it's at 5%; after four, 2%; and after five, slightly less than 1%. Although a theoretical, ideal capacitor will never fully discharge, we can say practically that it has done so after five time constants have elapsed.

RC Relaxation Oscillators. One circuit that is directly governed by the RC time constant is the *relaxation oscillator*. It depends on the alternate charging and discharging of a capacitor through a resistance. Probably the simplest relaxation oscillator you can build is a neon lamp flasher, shown in Fig. 4. The circuit is similar to that of Fig. 2, but we have added a neon bulb in parallel with the

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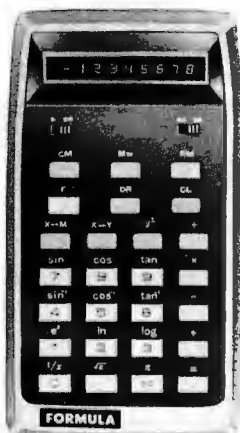
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capacitor. Until a certain voltage threshold is reached, the bulb acts like a very high resistance, practically an open circuit. Once the threshold is exceeded, the bulb turns on (conducts current and glows). In its on state, the bulb acts like a low resistance and will conduct very heavily unless a series current-limiting resistor is used with it. For common neon bulbs, the turn-on threshold is about 70 volts.

When the battery is connected, the capacitor starts charging up at a rate dependent on the time constant. After about 1.3 RC seconds have passed, the bulb suddenly turns on and discharges the capacitor very quickly. When the capacitor is discharged, no more current can flow through the bulb so it turns off. Then the capacitor begins to charge again. Oscillations, which we perceive as the flashing of the neon lamp, will continue as long as sufficient voltage is applied across the RC combination. You can duplicate this circuit very easily. Use an NE-2 neon bulb, a 90-volt photoflash battery, a small capacitor (0.1 μ F or less at 250 WVDC), and a large resistance (over two megohms). You can vary the flashing rate by changing R or C, or both. Just stay within the guidelines suggested above.

A more up-to-date relaxation oscillator is shown in Fig. 5. It uses the 741 op amp as a comparator, and produces high-amplitude square waves. Here's how it works. Assume a positive output voltage appears when we initially apply power. This charges C through R to a positive voltage. Charging proceeds until the voltage across the capacitor exceeds that applied to the noninverting (+) input by the voltage divider R1R2. At this point the comparator produces a large negative output voltage, which discharges the capacitor through R and starts to charge it to a negative voltage. When the voltage across the capacitor exceeds that at the (+) input of the op amp, the output voltage goes positive, and the process repeats itself.

The RC time constant controls the duration of the high (t₁) and low (t₂) output durations. The presence of the voltage divider and the value of the power supply voltage also play a role. For the values given in Fig. 5, the period T for a complete oscillation equals the sum of t₁ and t₂, or T = 0.9 RC, and the frequency f = 1/T = 1/990 \times 10⁶, or approximately 1000 Hz. If we increase C to 5 μ F, we get about one pulse per second. \diamond

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Hallicrafters Model SX-28 receiver, US Navy version RBY. Manufactured in the late '50's. Any available information. A.H. Heidorn, 795 Yale Dr., Barstow, CA 92311.

Back issue (April 1971) of PE needed. Arthur Kneller, 84 Bennett Avenue, Neptune City, NJ 07753.

Vogue Inst. Corp. (Richmond Hill, NY) Model 880 Printer. Manual or schematics. W.M. Lowe, 3312 Bellevue Ave., Cheverly, MD 20785

Scientific Development Corp. (Watertown, MA) MINIVAC 6010 relay computer. Operation manual. Robert Todd, 2720 E. 69th Place, Tulsa, OK 74135.

Brush Instruments Ultralinear oscillograph, Model RD-2662-00, Serial 125. Schematic and/or operation manual. Paul D. Witman, 2794 Harrington Rd., Simi Vly, CA 93065.

Mercury Model 4000 transistorized high impedance multimeter. Operation manual and/or schematic. Haydn J. Thomas, Apt. 7B, 120 E. 34th St., New York, NY 10016.

RCA station allocator stock, no. 171, 1942 model used to reset pushbutton radios. Need schematic from inside bottom cover. Bailey, 426 Slocum Avenue, Neptune, NJ 07753.

Beckman Ultrahmmeter. Instruction sheet or manual. Jacob Zager, 1 Mason Street, Hudson, MA 01749.

Precise Dev. Corp. Model 3052 D/rack mount dual trace oscilloscope. Schematic and/or service and calibration data. John F. Twitty, 218-15 136 Avenue, Springfield Gardens, NY 11413

Electronic Measurement Corp. Model 300 VTVM. Schematic and/or service manual. **Dumont** Model 185-A electronic switch and square wave generator. Schematic, service and operations manuals. **Electronic Beam Corp.** (Yonkers, NY) CRT checker and reactivator. No model number on case. Schematic, parts list, operation manual. Jack Manzik, 2810 Genesee Rd., Lawtons, NY 14091

Westinghouse Model H-196 TV receiver chassis V-2130 circa 1948-9. Horizontal Sync Discriminator transformer needed, primary 42 ohms CT, secondary part no. V 5935, or substitute. J.B. Swartz, R.R. 1, Box 1557BC, Camden-ton, MO 65020.

Jackson Models CRO-2 oscilloscope, 640 test oscillator. Schematics and operation manuals needed. R.E. Hutchinson, Rt. 3, Box 236, Arkadelphia, AR 71923.

Fairchild Camera and Instrument Model 7050 DVM. **Heath** Model OM-2 oscilloscope. Schematics and manuals needed. Larry Pearson, 1053 Hilltop Road, Warminster, PA 18974.

Knight Kit KN 330 AM/FM stereo receiver Serial 95DU 060. Schematic or power transformer data needed. Don Os-mund, WB9LWN, 533 Brainerd Avenue, Libertyville, IL 60048.

Polycom Model 2 transceiver, **Crown Telephone** Valet Model CTA-4400 K-85. Instruction books and/or schematics. Ian G. Tervet, Rte. 1, Box 45B, Little Rock, CA 93543.

Texas Instruments Model TI-3500 alculator. Schematic needed. Jim Walton, 1711 N. Mills Ave., Orlando, FL 32803.

U.S. Navy Model RBB-1 receiver covering 0.5 to 9 MHz, built by RCA. Need schematic, any other information, and a source for the male power connector. Warren E. Green-berg, 145 Cottage Rd., Roxbury, MA 02132.

Lafayette Model KT-208 signal generator. Need audio choke or substitute information, or a defective unit for parts. **Echo-Zonic** Model 109-B echo and reverb unit. Need schematic and set-up info. **Paco** T-60 tube tester. Meter needed. **RAC** tune-up meter. Need type numbers for all semiconductors. Nicholas I. Oshana, Jr., 141 Trolley Crossing Lane, Middletown, CT 06457.

Philco Model UN-2620-WH 15-inch B&W portable TV. Schematic, parts list, pc board artwork, and any other info. Michael S. Toth, Rt. 2, Box 40-A, Federsburg, MD 21632.

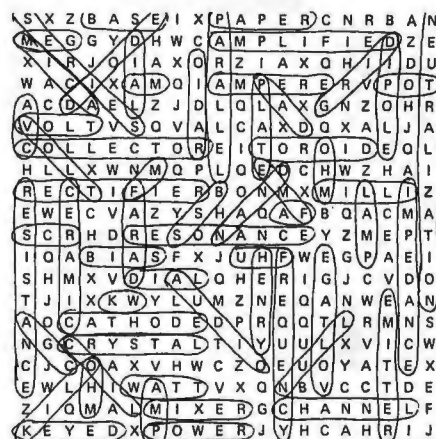
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Precise Model 300 oscilloscope. Schematic, instructions, and/or service manual needed. Daniel Evans, Box 4227, Huachuca City, AZ 85616.

Chicago Coin Co. "Playtime" pinball machine model 363 300. Schematic needed. M. Hunt, Cedar Hills, R.D. 3, Cambridge, OH 43725.

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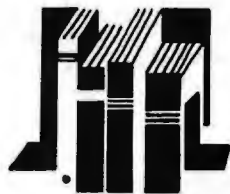
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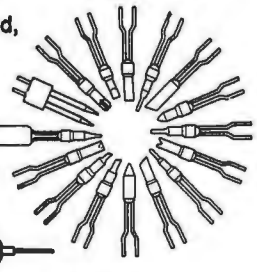
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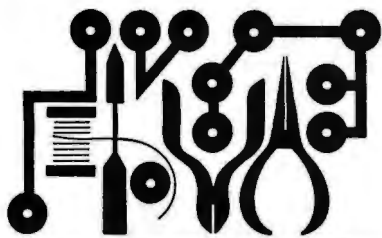
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POPULAR ELECTRONICS



Experimenter's Corner

By Forrest M. Mims

HIGH-VOLTAGE DC/DC CONVERTERS

IN THIS day of low-voltage semiconductor circuits that are often battery-powered, electronics experimenters rarely use more than 10 or 15 volts for their projects. But, although vacuum-tube projects are becoming increasingly rare, there are still many requirements for high voltages in modern circuits. For example, neon lamps require 60 to 70 volts, semiconductor laser pulse power supplies require up to several hundred volts, and xenon flash tubes require several hundred discharge volts and several kilovolts of trigger potential. Other high voltage components include photomultiplier tubes, helium-neon laser tubes, and image converters.

Some of the more exotic components that require a high operating potential are far too expensive for the average hobbyist, but many HV components are readily available. Advertisers in this magazine regularly offer such goodies as neon glow lamps, laser tubes, laser diodes, Panaplex™ displays, and assorted HV capacitors, SCR's, triacs, and rectifiers.

Several different circuits can be used to generate the high voltages required by these and other components. The most common up-

converters are powered by household line current. This, of course, poses a safety problem in addition to the HV output and limits portability to the length of the power cord. For this reason miniature solid-state dc-to-dc voltage converters that operate from low-voltage batteries are very popular with both engineers and experimenters who require a high-voltage power supply.

Dc-to-dc Converters. Let's examine two very simple dc-to-dc converters that can be used in low-current, high-voltage applications. The first circuit, shown in Fig. 1, is ultra-simple and illustrates the miniaturization potential of a solid-state high-voltage power supply.

The circuit is a modified Hartley oscillator that uses an ordinary audio input transformer for the inductor. The low-impedance, center-tapped secondary supplies the feedback required to start and maintain oscillation. The pulses generated by the oscillator pass through the secondary winding, where they are inductively coupled into the primary. The transformer steps up the input from a few volts of steady dc to several hundred volts of rapidly pulsating current.

To give some idea of the performance of this potent circuit, here's a table of the outputs I measured for a range of input voltages:

Input (volts)	Output (volts)
0.5	1
1.0	200
2.0	440
3.0	625
4.0	800
5.0	900
6.0	1000

These potentials were measured under open-circuit conditions. When the converter is connected to an output device, the subsequent load will reduce the output voltage. Neverthe-

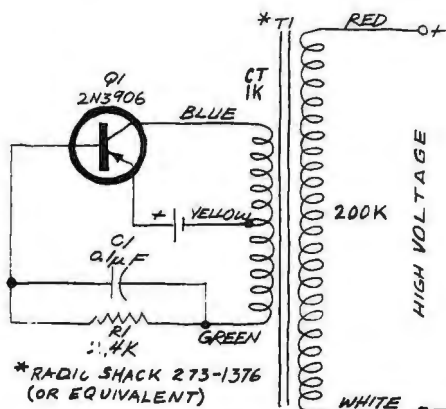
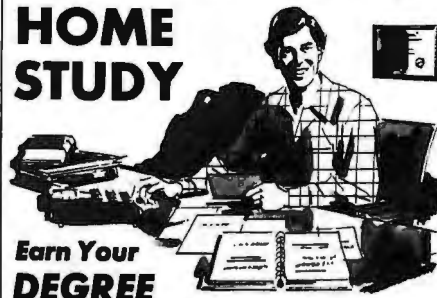


Fig. 1. Simple dc/dc converter.

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less, the performance of the circuit is quite impressive. Incidentally, with the component values specified, the oscillator frequency ranged from 344 to 574 Hz over the range of input voltages. The pulse width was a relatively constant 150 μ s.

The current output of this circuit is minuscule, but it can easily ionize a neon lamp or power a semiconductor laser power supply. It can also operate the simple neon-lamp relaxation oscillator shown in Fig. 2. This circuit will flash about once a second with the component values shown. In operation, C_1 charges through R_1 until the breakdown voltage of I_1 is reached. When I_1 fires, C_1 discharges through I_1 , and the cycle repeats. Diode D_1 keeps C_1 from discharging back through the transformer winding.

A single 1.5-volt cell will provide enough power when using the dc-to-dc converter to operate neon lamps. Since a neon lamp requires 60 to 70 volts for operation, this provides an impressive demonstration of the circuit's high-voltage capability.

The current drain of the Fig. 1 circuit connected to the neon flasher in Fig. 2 is fairly low. The circuit draws 12.3 mA from a fresh D cell at 1.5 volts, 8.3 mA from a fully charged 1.2-volt nickel-cadmium cell, and only 6.8 mA from a 1-volt source.

The simple circuit in Fig. 1 is typical of most dc-to-dc converters in that the transformer plays an active role in both the oscillator and HV sections of the circuit. Dc-to-dc converters can also be designed so that the transformer functions strictly as a voltage converter. One possibility is shown in Fig. 3, where a unijunction transistor oscillator is connected to a high-turns-ratio input transformer like the one used in Fig. 1. The oscillator produces a series of fast risetime pulses each time C_1 discharges through the emitter-to-B1 junction of Q_1 . The pulses are passed through the low-impedance winding of the transformer

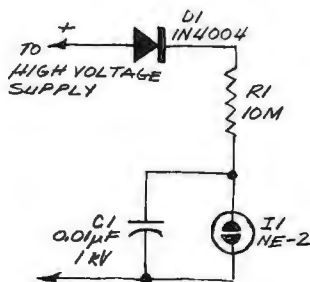


Fig. 2. Neon relaxation oscillator.

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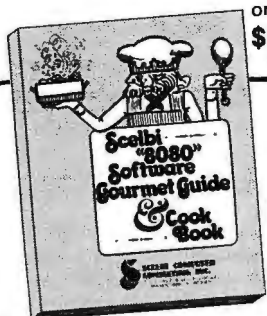
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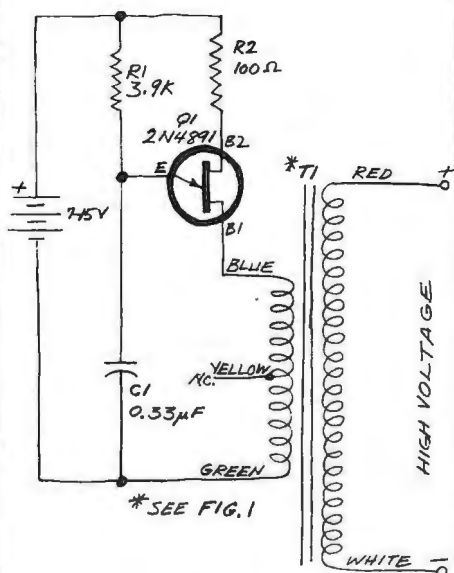


Fig. 3. UJT dc/dc converter.

and induced into the high-impedance winding as high voltage pulses.

Due to the presence of the unijunction transistor, the circuit in Fig. 3 requires a higher operating voltage (7 to 15 volts) than the circuit in Fig. 1. But at 10 volts the circuit will operate the neon flasher in Fig. 2 with a current drain of only 0.5 mA. This corresponds to a total power consumption of about 5 mW versus about 18 mW for the previous circuit.

Conclusion. The two simple dc-to-dc converters described in this column are adequate for powering neon lamps, diode-laser pulse generators, and other low-current devices. If you have access to an oscilloscope, you can watch the output voltages while tinkering with the values of $R1$ and $C1$ in both circuits to optimize the operating conditions. More powerful converters are required for many HV applications, and a subsequent column will continue this interesting subject with a couple of additional dc-to-dc converters.

Meanwhile, try experimenting with the circuits described here to get experience. Finally, always use care when experimenting with any high-voltage circuit. Small size and low battery voltage mean little when high voltage is present! A low-current shock may not harm you, but the resulting reflex jerk may injure a hand, arm, or elbow and knock items from your workbench. A high-current shock, such as from a charged capacitor, can be fatal.



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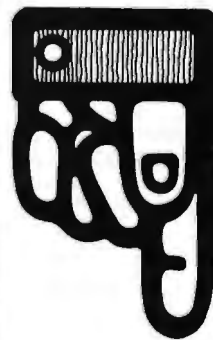
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SN74162N	LM324N	1.10	CD4082	.55	8129	.25
SN74163N	LM324N	1.10	CD4083	.55	8129	.25
SN74164N	LM324N	1.10	CD4084	.55	8129	.25
SN74165N	LM324N	1.10	CD4085	.55	8129	.25
SN74166N	LM324N	1.10	CD4086	.55	8129	.25
SN74167N	LM324N	1.10	CD4087	.55	8129	.25
SN74168N	LM324N	1.10	CD4088	.55	8129	.25
SN74169N	LM324N	1.10	CD4089	.55	8129	.25
SN74170N	LM324N	1.10	CD4090	.55	8129	.25
SN74171N	LM324N	1.10	CD4091	.55	8129	.25
SN74172N	LM324N	1.10	CD4092	.55	8129	.25
SN74173N	LM324N	1.10	CD4093	.55	8129	.25
SN74174N	LM324N	1.10	CD4094	.55	8129	.25
SN74175N	LM324N	1.10	CD4095	.55	8129	.25
SN74176N	LM324N	1.10	CD4096	.55	8129	.25
SN74177N	LM324N	1.10	CD4097	.55	8129	.25
SN74178N	LM324N	1.10	CD4098	.55	8129	.25
SN74179N	LM324N	1.10	CD4099	.55	8129	.25
SN74180N	LM324N	1.10	CD4100	.55	8129	.25
SN74181N	LM324N	1.10	CD4101	.55	8129	.25
SN74182N	LM324N	1.10	CD4102	.55	8129	.25
SN74183N	LM324N	1.10	CD4103	.55	8129	.25
SN74184N	LM324N	1.10	CD4104	.55	8129	.25
SN74185N	LM324N	1.10	CD4105	.55	8129	.25
SN74186N	LM324N	1.10	CD4106	.55	8129	.25
SN74187N	LM324N	1.10	CD4107	.55	8129	.25
SN74188N	LM324N	1.10	CD4108	.55	8129	.25
SN74189N	LM324N	1.10	CD4109	.55	8129	.25
SN74190N	LM324N	1.10	CD4110	.55	8129	.25
SN74191N	LM324N	1.10	CD4111	.55	8129	.25
SN74192N	LM324N	1.10	CD4112	.55	8129	.25
SN74193N	LM324N	1.10	CD4113	.55	8129	.25
SN74194N	LM324N	1.10	CD4114	.55	8129	.25
SN74195N	LM324N	1.10	CD4115	.55	8129	.25
SN74196N	LM324N	1.10	CD4116	.55	8129	.25
SN74197N	LM324N	1.10	CD4117	.55	8129	.25
SN74198N	LM324N	1.10	CD4118	.55	8129	.25
SN74199N	LM324N	1.10	CD4119	.55	8129	.25
SN74200N	LM324N	1.10	CD4120	.55	8129	.25
SN74201N	LM324N	1.10	CD4121	.55	8129	.25
SN74202N	LM324N	1.10	CD4122	.55	8129	.25
SN74203N	LM324N	1.10	CD4123	.55	8129	.25
SN74204N	LM324N	1.10	CD4124	.55	8129	.25
SN74205N	LM324N	1.10	CD4125	.55	8129	.25
SN74206N	LM324N	1.10	CD4126	.55	8129	.25
SN74207N	LM324N	1.10	CD4127	.55	8129	.25
SN74208N	LM324N	1.10	CD4128	.55	8129	.25
SN74209N	LM324N	1.10	CD4129	.55	8129	.25
SN74210N	LM324N	1.10	CD4130	.55	8129	.25
SN74211N	LM324N	1.10	CD4131	.55	8129	.25
SN74212N	LM324N	1.10	CD4132	.55	8129	.25
SN74213N	LM324N	1.10	CD4133	.55	8129	.25
SN74214N	LM324N	1.10	CD4134	.55	8129	.25
SN74215N	LM324N	1.10	CD4135	.55	8129	.25
SN74216N	LM324N	1.10	CD4136	.55	8129	.25
SN74217N	LM324N	1.10	CD4137	.55	8129	.25
SN74218N	LM324N	1.10	CD4138	.55	8129	.25
SN74219N	LM324N	1.10	CD4139	.55	8129	.25
SN74220N	LM324N	1.10	CD4140	.55	8129	.25
SN74221N	LM324N	1.10	CD4141	.55	8129	.25
SN74222N	LM324N	1.10	CD4142	.55	8129	.25
SN74223N	LM324N	1.10	CD4143	.55	8129	.25
SN74224N	LM324N	1.10	CD4144	.55	8129	.25
SN74225N	LM324N	1.10	CD4145	.55	8129	.25
SN74226N	LM324N	1.10	CD4146	.55	8129	.25
SN74227N	LM324N	1.10	CD4147	.55	8129	.25
SN74228N	LM324N	1.10	CD4148	.55	8129	.25
SN74229N	LM324N	1.10	CD4149	.55	8129	.25
SN74230N	LM324N	1.10	CD4150	.55	8129	.25
SN74231N	LM324N	1.10	CD4151	.55	8129	.25
SN74232N	LM324N	1.10	CD4152	.55	8129	.25
SN74233N	LM324N	1.10	CD4153	.55	8129	.25
SN74234N	LM324N	1.10	CD4154	.55	8129	.25
SN74235N	LM324N	1.10	CD4155	.55	8129	.25
SN74236N	LM324N	1.10	CD4156	.55	8129	.25
SN74237N	LM324N	1.10	CD4157	.55	8129	.25
SN74238N	LM324N	1.10	CD4158	.55	8129	.25
SN74239N	LM324N	1.10	CD4159	.55	8129	.25
SN74240N	LM324N	1.10	CD4160	.55	8129	.25
SN74241N	LM324N	1.10	CD4161	.55	8129	.25
SN74242N	LM324N	1.10	CD4162	.55	8129	.25
SN74243N	LM324N	1.10	CD4163	.55	8129	.25
SN74244N	LM324N	1.10	CD4164	.55	8129	.25
SN74245N	LM324N	1.10	CD4165	.55	8129	.25
SN74246N	LM324N	1.10	CD4166	.55	8129	.25
SN74247N	LM324N	1.10	CD4167	.55	8129	.25
SN74248N	LM324N	1.10	CD4168	.55	8129	.25
SN74249N	LM324N	1.10	CD4169	.55	8129	.25
SN74250N	LM324N	1.10	CD4170	.55	8129	.25
SN74251N	LM324N	1.10	CD4171	.55	8129	.25
SN74252N	LM324N	1.10	CD4172	.55	8129	.25
SN74253N	LM324N	1.10	CD4173	.55	8129	.25
SN74254N	LM324N	1.10	CD4174	.55	8129	.25
SN74255N	LM324N	1.10	CD4175	.55	8129	.25
SN74256N	LM324N	1.10	CD4176	.55	8129	.25
SN74257N	LM324N	1.10	CD4177	.55	8129	.25
SN74258N	LM324N	1.10	CD4178	.55		

THE KING OF ALTAJ 25.50



8-DIGIT ALARM CLOCK

THE KING FEATURES:

- 1) 6 digit, 12 hr. 60 cycle or 24 hr. 50 cycle alarm clock.
- 2) Time sharing capability for display of additional information.
- 3) Single 12v. supply and a minimum of interface components.
- 4) AM-PM and automatic power failure indications.
- 5) 10 minute snooze.
- 6) Intensity control of LEDs.

Kit No. 70250-1R (red readouts)
Kit No. 70250-1G (green readouts)
Kit No. 70250-1Y (yellow readouts)
Kit No. 70250-2R (DL727 readouts) \$19.50
Kit No. 70250-3R (FND807 readouts) \$19.50

All kits include components, PC Boards, Transformer, case, and construction manual.

THE KING'S HAREM

FATIMA 4-DIGIT TEMP. KIT \$24.95

Features 4-digit temperature display; Fahrenheit or Centigrade; complete CMOS application; uses 7002 4-digit counter.

Kits include all components, PC Board and instructions for interfacing with THE KING 8-digit alarm clock. Addt'l Number 1

DELILA APPLIANCE STARTER \$9.95

(Example) Set your alarm for 7: a.m., set timer for 15 min. At exactly 7: a.m., the appliance will start; at 7:15 your clock alarm will wake you.

Kit includes all components, PC Board and instructions for interfacing with THE KING 8-digit alarm clock. Addt'l Number 2

TANYA 60 HZ CRYSTAL TIME BASE \$5.95

ADDITIONAL FEATURES:

- 1) Low Power Consumption
- 2) Directly interfaces with King MOS Clock Chip.
- 3) 60 Hz output with crystal time base accuracy
- 4) Ideal for Cars, Boats, & Campers.

Kit includes all components, PC Board and instructions for interfacing with THE KING 8-Digit Alarm Clock. Addt'l Number 3

FND 70
RED, 25 In. Char.
15mA per segment.
Common Cathode.
\$1.25

DL787
One of our best readouts
5 in. high, 20mA per
segment. Common anode.
\$3.75

FND803
New 5 in. display
by Fairchild.
Common Cathode.
\$1.50
\$1.50

FND807 **ANDOR**
FND 800 **CATHODE**
5 in. High. The Best
on the market. Ideal
for large readout
application. \$4.95
\$2.50 in high orange
digit. 160V dc.
Free socket. \$2.50

LEDS
Mini red .12
Jumbo red .15
Jumbo green .20
Jumbo yellow .25
Fully multiplexed common cathode.
Goldplated. Ideal for mini 6 digit
clock. \$1.30

DL33
If you have an array of displays,
we have it. Common
cathodes. \$1.45

TTL BOARDS

MEMOREX computer boards with TTL's Diodes and Transistors, etc.

5 Boards containing 150-250 IC's \$4.50

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7008 used Darling., SCR's,
NPN, PNP, etc.
50 for \$1.50
100 for \$2.50
300 for \$8.00

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MM5316 - 4-8 digit alarm clock 40 pin dip w/spec. \$ 4.25
7002 - 4 digit counter/latch decoder; 7 segment and BCD outputs, 28 pin dip w/spec. \$12.50
7005 - 4 digit counter/latch decoder; 7 segment output only, 24 pin dip w/spec. \$ 9.50
7007 - 4 digit counter/latch decoder with BCD output only, 18 pin dip w/spec. \$ 7.00
70250 - 4-8 digit alarm clock 28 pin dip w/spec. \$ 5.50
PC Board for 70250 \$ 4.25
70350 - 4 digit non-multiplexed radio alarm clock featuring direct drive display output 40 pin dip w/spec. \$4.50
PC Board for 70350 \$ 3.75
8008 - 8 bit parallel CPU \$10.50
2102 - 1K static RAM for 8008 \$ 2.25
MM5203 - 2K UV erasable PROM \$12.25
75491 - segment driver \$ 0.35
75492 - digit driver \$ 0.45
7020 - 6 function calculator chip with direct segment drive, 8 digit \$ 2.25

TTL

7400	-21	7448	-.84	74151	-.80
7402	-21	7453	-.21	74153	-.84
7404	-21	7473	-.42	74154	-1.00
7406	-29	7474	-.42	74161	-1.04
7408	-21	7475	-.20	74163	-1.24
7410	-21	7476	-.44	74164	-1.84
7413	-.54	7483	-.80	74174	-1.34
7420	-21	7489	2.50	74175	-1.44
7427	-29	7490	-.74	74181	-2.80
7430	-21	7492	-.80	74182	-1.30
7437	-.44	7493	-.80	74183	-1.30
7438	-.39	7495	-.80	74189	-.84
7440	-21	7496	-.80	74191	-.84
7442	-.74	7421	-.43		
7447	-.94	7423	-.80		

CMOS

4000	-.24	4018	-1.48	4037	4.50
4001	-.24	4019	-.88	4040	1.59
4002	-.24	4020	-1.59	4041	-.89
4006	-1.48	4021	-1.49	4042	-.79
4007	-.24	4022	-.19	4043	-.80
4008	-1.15	4023	-.24	4044	-.59
4009	-.59	4024	-.59	4047	-.59
4010	-.55	4025	-.24	4049	-.59
4011	-.24	4027	-.59	4050	-.59
4012	-.24	4028	-.59	4066	-.99
4013	-.59	4029	-1.39	74C02	-.29
4014	-1.49	4030	-.40	74C04	-.29
4015	-1.19	4034	-3.25	74C07	-1.29
4016	-.59				
4017	-1.29	4035	-1.39		

4 & 6 DIGIT PC BOARDS

PC Board for 4 digit display FND 800 or 807 \$2.75
PC Board for 6 digit display FND 800 or 807 \$3.50
PC Board for 4 digit display MAN series or DL707 \$3.75
PC Board for 6 digit display MAN series or DL707 \$3.75
PC Board for 4 digit display FND503 \$2.50
PC Board for 6 digit display FND503 \$2.50
PC Board for 4 digit display DL747 \$2.50
PC Board for 6 digit display DL747 \$2.50
PC Board for 4 digit display DL727 \$2.50
PC Board for 6 digit display DL727 \$2.50
PC Board for 4 digit display FND70 \$2.75
All PC display boards are multiplexed for adding additional digits.



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Now you can build some of the most advanced digital electronic instruments with our new series of low-cost modular scientific kits. These kits will expand the range of your electronic applications enormously—and all at a surprisingly low cost.

The heart of the system is our 4-digit Decade Counter (Kit 012) which features a full 4-digit LED readout (you choose the size best suited to your application). Combine this with a 5-volt regulated power supply (Kit 030) and you have the basis of a wide range of sophisticated electronic instruments, including:

A Digital Voltmeter (DVM) ... Kit 012 + Kit 030 + Kit 017
Frequency Counter ... Kit 012 + Kit 030 + Kit 018 + Time Base
RPM Counter ... Kit 012 + Kit 030 + Kit 020 + Kit 018

4-DIGIT DECADE COUNTER KIT \$19.95 KIT 012

One chip 4 digit decade counter kit, with both 7 segment and BCD output.

1. Chip features internal oscillator for scanning speed.
2. Overflow and count extant outputs.
3. Transfer, reset, count, blanking and true complement control inputs.
4. PC Board can be cascaded to 8-12-16, etc. digits.
5. Kit includes counter chip, drive circuit for 4 cathode type displays and PC Board. (For readout board see FND70/FND803)

KIT 018 FREQ. COUNTER

Features FET input front end with trigger circuit for measuring complex waveforms. Measures from 0.1Hz to 10MHz when used with Kit 015 or 019. Measures from .01Hz to 35MHz when used with Kit 013 and 014. \$24.95

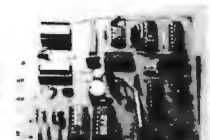


KIT 030 POWER SUPPLY

*Input voltage: 25V max. *Output current: 1 amp max.
*Load regulation: 50mV. *Output voltage: 5V. *Line regulation: .01%. (Requires 5-20V transformer) \$4.55
(Contains all parts except transformer)

KIT 017 DVM

1.800V as basic, with polarity indication. 1 M ohm input impedance and accuracy to 1% if properly adjusted. \$16.50



TIME BASES

1 MHz crystal chain time base divider. Outputs: 1MHz 100KHz-10KHz-100Hz-10Hz-1Hz-0.1Hz. Accuracy better than .005% with proper adjustment.

Kit 013 complete CMOS with PC board \$16.75
Buffer Circuit for TTL Interfacing

Kit 014 Same as Kit 013, but with TTL..... \$12.75

Kit 015 60Hz or 60KHz chain time base using line frequency as reference. Accuracy 0.1-0.05%. Outputs 10Hz-1Hz-0.1Hz. Complete with CMOS shaping circuit and PC Board..... \$8.75

Kit 019 Same as Kit 015, but with TTL and 60Hz only..... \$7.75

Kit 018 60KHz chain time base using line frequency for Kit 020 RPM counter.

*Outputs: 8 sec. = 100th of RPM
6 sec. = 10th of RPM
60 sec. = full revolution \$9.75



KIT 020 RPM COUNTER

Counts from 1 to 100,000 RPM. RPM counter kit contains components and PC board. \$8.95

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Send for your membership card to the Modular Scientific Instrumentation Club and receive a big 15% off on future purchases of M.S.I. kits. Send \$3.00 with your name and address. We will promptly send your very own registered membership card. Don't miss out on the savings. Write now.

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\$\$\$ SAVE! 4-DIGIT ALARM CLOCK

KIT NO. 1 \$13.95 (with PC Board)

FEATURES:

Direct drive display outputs. * Current control regulation on chip. * Low power brightness control on chip. * RFI eliminating slowup circuitry. * Sleep Radio feature. * 24 hr. snooze alarm. * Independent digit setting. * Non multiplexed output circuitry. 12VAC T 1/2 amp transformer for Kit No. 1 \$2.00

*KIT NO. 2

Complete kit with components, PC Board, Transformer, wood grain case and filter for display window. Includes 25 in readouts. \$21.50

KIT NO. 3

Complete kit with components, PC Board, Transformer, wood grain case, and filter for display window. Includes 5 inch readouts. \$22.50

* Components for Kit No. 2 or Kit No. 3 sleep radio feature, add \$3.95



LINEARS

555 Timer Mini dip
8038 Functional generator
RCA 3043 FM II, Aud. Preamp.
565 Phase Lock Loop
567V Tone Decoder
LM723 Pos. Volt. Reg.
LM309 Dv. I amp Reg
LM380 Dv. Audio Amp. 8 pin dip
LM741 Operational Amp.



TRANSISTORS-DIODES

0.65	RCA200V 15W TOS NPN	1.25
0.25	GE D40C1 NPN Darl.	0.25
0.65	2N4443SCR 400mA T0220	0.65
0.20	2N2222 NPN Gen. Ampl.	0.20
0.15	2N2904 NPN Driver	0.15
0.15	2N3906 PNP Compl. 2N3904	0.15
0.20	2N4400 NPN Low level noise	0.20
0.25	2N5401 PNP Mixer driver	0.25
1.00	1N4004 400PIV	15 for 1.00
1.00	1N4007 4000PIV	10 for 1.00
1.00	1N746 3.3 Zen.	4 for 1.00
0.25	1N4148 Switch	20 for 1.00



COMPLETELY SELF CONTAINED UNIT WITH 120 VOLT POWER CORD INCLUDED. \$2.00

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Power Supply Kit: 5 Volt 1 Amp. Reg.
Line regulation .005%
Load regulation 50mV

Kit includes Components, PC Board, Transf., Fuse, Pilot Light
Nothing else to buy: \$8.50

TTL 7400N

SN7400N	.15	SN74121N	.36
SN7401N	.15	SN74122N	.42
SN7402N	.15	SN74123N	.59
SN7403N	.15	SN74125N	.45
SN7404N	.18	SN74126N	.45
SN7405N	.18	SN74128N	.65
SN7406N	.18	SN74132N	.84
SN7407N	.34	SN74136N	.64
SN7408N	.18	SN74141N	.53
SN7409N	.18	SN74142N	3.70
SN7410N	.15	SN74143N	3.98
SN7411N	.21	SN74144N	3.98
SN7412N	.28	SN74145N	.89
SN7413N	.41	SN74147N	1.68
SN7414N	.79	SN74148N	1.25
SN7416N	.26	SN74150N	.99
SN7417N	.31	SN74151N	.63
SN7420N	.15	SN74153N	.63
SN7421N	.21	SN74154N	.99
SN7422N	.21	SN74155N	.78
SN7423N	.27	SN74156N	.69
SN7425N	.27	SN74157N	.64
SN7426N	.24	SN74159N	2.50
SN7427N	.27	SN74160N	.89
SN7428N	.35	SN74161N	.89
SN7430N	.15	SN74162N	.89
SN7432N	.24	SN74163N	.89
SN7433N	.35	SN74164N	1.10
SN7437N	.23	SN74165N	.99
SN7438N	.23	SN74166N	1.19
SN7440N	.15	SN74167N	2.98
SN7442N	.38	SN74170N	1.75
SN7443N	.85	SN74172N	8.75
SN7444N	.85	SN74173N	1.29
SN7445N	.74	SN74174N	.99
SN7446N	.74	SN74175N	.89
SN7447N	.74	SN74176N	.79
SN7448N	.74	SN74177N	.78
SN7450N	.15	SN74178N	1.25
SN7451N	.15	SN74179N	1.60
SN7453N	.15	SN74180N	.89
SN7454N	.15	SN74181N	1.99
SN7456N	.15	SN74182N	.89
SN7460N	.15	SN74184N	1.89
SN7470N	.28	SN74185AN	1.85
SN7472N	.27	SN74186N	6.95
SN7473N	.31	SN74188N	3.50
SN7474N	.31	SN74190N	1.09
SN7475N	.48	SN74191N	1.09
SN7476N	.34	SN74192N	.88
SN7480N	.39	SN74193N	.88
SN7481AN	.99	SN74194N	.94
SN7482N	.59	SN74195N	.59
SN7483AN	.69	SN74196N	.93
SN7484AN	1.65	SN74197N	.83
SN7485N	.88	SN74198N	1.69
SN7486N	.32	SN74199N	1.69
SN7489N	1.95	SN74221N	1.20
SN7490AN	.45	SN74246N	1.95
SN7491AN	.64	SN74247N	1.85
SN7492AN	.46	SN74248N	1.75
SN7493AN	.46	SN74249N	1.75
SN7494N	.74	SN74251N	1.40
SN7495AN	.69	SN74285N	.85
SN7496N	.69	SN74278N	2.45
SN7497N	2.85	SN74279N	.59
SN74100N	.99	SN74283N	1.45
SN74104N	.43	SN74284N	4.50
SN74105N	.43	SN74285N	4.50
SN74107N	.29	SN74290N	.85
SN74109N	.49	SN74293N	.85
SN74110N	.54	SN74298N	1.98
SN74111N	.74	SN74351N	1.92
SN74116N	1.75	SN74365N	.65
SN74120N	1.40	SN74366N	.85
		SN74367N	.85
		SN74368N	.85
		SN74390N	1.40
		SN74393N	1.40
		SN74490N	1.90

ZENER DIODES

IN4728-IN4752A	.19
(1 watt molded)	
IN746A-IN759A	.15
(400 MW)	

TTL LOW POWER SCHOTTKY

SN74LS00N	.25	SN74LS138N	1.49
SN74LS01N	.25	SN74LS139N	1.49
SN74LS02N	.25	SN74LS145N	1.25
SN74LS03N	.25	SN74LS151N	1.25
SN74LS04N	.30	SN74LS153N	1.25
SN74LS05N	.30	SN74LS155N	1.45
SN74LS08N	.25	SN74LS156N	1.45
SN74LS09N	.25	SN74LS157N	1.25
SN74LS10N	.25	SN74LS158N	1.20
SN74LS11N	.25	SN74LS160N	1.95
SN74LS12N	.25	SN74LS161N	1.95
SN74LS13N	.69	SN74LS162N	1.95
SN74LS14N	1.35	SN74LS163N	1.95
SN74LS15N	.25	SN74LS164N	1.98
SN74LS20N	.25	SN74LS168N	2.25
SN74LS21N	.25	SN74LS169N	2.25
SN74LS22N	.25	SN74LS170N	2.80
SN74LS26N	.40	SN74LS174N	1.40
SN74LS27N	.30	SN74LS175N	1.40
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SN74LS48N	1.10	SN74LS197N	1.45
SN74LS47N	1.10	SN74LS221N	1.35
SN74LS48N	1.10	SN74LS240N	2.50
SN74LS49N	1.10	SN74LS241N	2.50
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SN74LS54N	.25	SN74LS243N	2.40
SN74LS55N	.25	SN74LS244N	2.50
SN74LS63N	1.75	SN74LS247N	1.30
SN74LS73N	.49	SN74LS248N	1.30
SN74LS74N	.49	SN74LS249N	1.30
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TIL116	1
TIL117	
TIL118	
TIL119	
TIL138	2
TIL139	2
TIL209A	
TIL211	
TIL220	
TIL221	
TIL222	
TIL23	1
TIL24	3
TIL302	3
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TIL306	7
TIL307	7
TIL308	7
TIL309	7
TIL311	8
TIL312	1
TIL313	1
TIL31	1
TIL32	
TIL63	
TIL86	
TIL78	
TIL81	1
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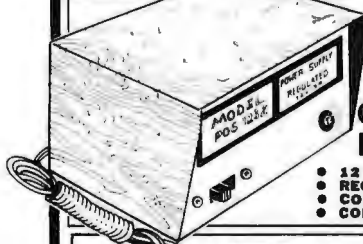
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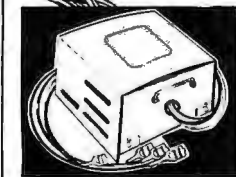


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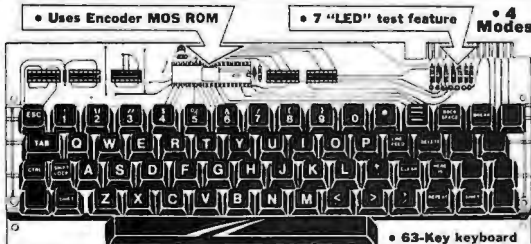
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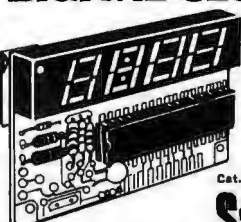
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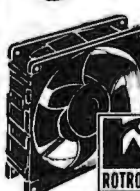
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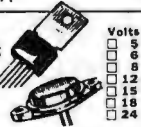
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SN7403	.22	.23	SN74125	1.29	1.30
SN7404	.24	.25	SN74126	1.29	1.30
SN7406	.36	.37	SN74132	1.95	1.96
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SN7408	.22	.23	SN74145	1.69	1.70
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SN7411	.27	.28	SN74153	1.10	1.11
SN7412	.62	.63	SN74154	1.53	1.54
SN7420	.22	.23	SN74157	1.09	1.10
SN7421	.65	.66	SN74158	1.55	1.56
SN7422	.47	.48	SN74159	1.55	1.56
SN7423	.47	.48	SN74160	1.59	1.60
SN7425	.37	.38	SN74163	1.50	1.51
SN7430	.22	.23	SN74164	1.79	1.80
SN7432	.66	.67	SN74165	1.79	1.80
SN7440	.22	.23	SN74173	1.69	1.70
SN7442	.97	.98	SN74174	1.42	1.43
SN7445	.97	.98	SN74175	1.45	1.46
SN7446	1.10	1.11	SN74176	1.59	1.60
SN7448	1.10	1.11	SN74177	1.59	1.60
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NSN71L 1.19
NSN74 1.19
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320 1.39	382 1.75	748 .35
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DL10A 2.19	GREEN .15
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3-Switches
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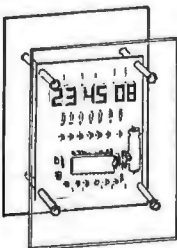
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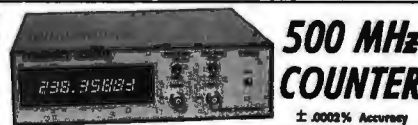
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7405	.21	7482	.70	74181	2.15	4009	.44	4510	1.14
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7408	.21	7486	.28	74185	2.19	4012	.23	4515	2.80
7409	.21	7489	2.19	74186	3.50	4013	.40	4516	1.23
7410	.21	7490	.44	74189	3.50	4014	.96	4518	1.14
7411	.21	7491	.70	74190	1.23	4015	.96	4520	1.14
7412	.21	7492	.44	74191	1.23	4016	.40	4527	1.88
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7414	.89	7494	.70	74193	.88	4018	1.05	4585	1.23
7415	.25	7495	.70	74194	.88	4019	.23	LM390K	1.80
7416	.25	7496	.70	74195	.88	4020	1.14	LM324N	1.28
7417	.25	7497	.70	74196	.88	4021	1.14	LM340T-1	1.25
7418	.25	7498	.70	74197	.88	4022	.93	LM340T-6	1.25
7419	.25	7499	.33	74198	1.49	4023	.23	LM340T-8	1.25
7420	.25	7499	.33	74199	1.49	4024	.84	LM340T-12	1.25
7421	.25	7499	.33	74200	1.49	4025	.23	LM340T-15	1.25
7422	.25	7499	.33	74201	1.49	4026	1.68	LM340T-18	1.25
7423	.25	7499	.33	74202	1.49	4027	.40	LM340T-24	1.25
7424	.25	7499	.33	74203	1.49	4028	.89	LM390K	.88
7425	.25	7499	.33	74204	1.49	4029	1.14	NE53AT	3.24
7426	.25	7499	.33	74205	1.49	4030	.23	NE540L	2.04
7427	.25	7499	.33	74206	1.49	4031	1.51	NE555V	.48
7428	.25	7499	.33	74207	1.49	4032	1.51	NE555V	.48
7429	.25	7499	.33	74208	1.49	4033	1.51	NE555V	.48
7430	.25	7499	.33	74209	1.49	4034	3.50	NE56A	.89
7431	.25	7499	.33	74210	1.49	4035	1.14	NE560B	3.83
7432	.25	7499	.33	74211	1.49	4036	1.14	NE561B	3.83
7433	.25	7499	.33	74212	1.49	4037	.40	NE561B	3.83
7434	.25	7499	.33	74213	1.49	4038	.40	NE561B	3.83
7435	.25	7499	.33	74214	1.49	4039	.40	NE561B	3.83
7436	.25	7499	.33	74215	1.49	4040	.40	NE561B	3.83
7437	.25	7499	.33	74216	1.49	4041	.40	NE561B	3.83
7438	.25	7499	.33	74217	1.49	4042	.40	NE561B	3.83
7439	.25	7499	.33	74218	1.49	4043	.40	NE561B	3.83
7440	.25	7499	.33	74219	1.49	4044	.40	NE561B	3.83
7441	.25	7499	.33	74220	1.49	4045	.40	NE561B	3.83
7442	.25	7499	.33	74221	1.49	4046	1.86	uA709CV	.44
7443	.25	7499	.33	74222	1.49	4047	.40	uA710CA	.44
7444	.25	7499	.33	74223	1.49	4048	.40	uA711CA	.44
7445	.25	7499	.33	74224	1.49	4049	.40	uA723CA	.53
7446	.25	7499	.33	74225	1.49	4050	.40	uA741CV	.44
7447	.25	7499	.33	74226	1.49	4051	.40	uA747CA	.44
7448	.25	7499	.33	74227	1.49	4052	1.26	uA748CV	.44
7449	.25	7499	.33	74228	1.49	4053	1.26	uA748CV	.44
7450	.25	7499	.33	74229	1.49	4054	1.26	uA748CV	.44
7451	.25	7499	.33	74230	1.49	4055	1.26	uA748CV	.44
7452	.25	7499	.33	74231	1.49	4056	1.26	uA748CV	.44
7453	.25	7499	.33	74232	1.49	4057	1.26	uA748CV	.44
7454	.25	7499	.33	74233	1.49	4058	1.26	uA748CV	.44
7455	.25	7499	.33	74234	1.49	4059	1.26	uA748CV	.44
7456	.25	7499	.33	74235	1.49	4060	1.26	uA748CV	.44
7457	.25	7499	.33	74236	1.49	4061	1.26	uA748CV	.44
7458	.25	7499	.33	74237	1.49	4062	1.26	uA748CV	.44
7459	.25	7499	.33	74238	1.49	4063	1.26	uA748CV	.44
7460	.25	7499	.33	74239	1.49	4064	1.26	uA748CV	.44
7461	.25	7499	.33	74240	1.49	4065	1.26	uA748CV	.44
7462	.25	7499	.33	74241	1.49	4066	1.26	uA748CV	.44
7463	.25	7499	.33	74242	1.49	4067	1.26	uA748CV	.44
7464	.25	7499	.33	74243	1.49	4068	1.26	uA748CV	.44
7465	.25	7499	.33	74244	1.49	4069	1.26	uA748CV	.44
7466	.25	7499	.33	74245	1.49	4070	1.26	uA748CV	.44
7467	.25	7499	.33	74246	1.49	4071	1.26	uA748CV	.44
7468	.25	7499	.33	74247	1.49	4072	1.26	uA748CV	.44
7469	.25	7499	.33	74248	1.49	4073	1.26	uA748CV	.44
7470	.25	7499	.33	74249	1.49	4074	1.26	uA748CV	.44
7471	.25	7499	.33	74250	1.49	4075	1.26	uA748CV	.44
7472	.25	7499	.33	74251	1.49	4076	1.26	uA748CV	.44
7473	.25	7499	.33	74252	1.49	4077	1.26	uA748CV	.44
7474	.25	7499	.33	74253	1.49	4078	1.26	uA748CV	.44
7475	.25	7499	.33	74254	1.49	4079	1.26	uA748CV	.44
7476	.25	7499	.33	74255	1.49	4080	1.26	uA748CV	.44
7477	.25	7499	.33	74256	1.49	4081	1.26	uA748CV	.44
7478	.25	7499	.33	74257	1.49	4082	1.26	uA748CV	.44
7479	.25	7499	.33	74258	1.49	4083	1.26	uA748CV	.44
7480	.25	7499	.33	74259	1.49	4084	1.26	uA748CV	.44
7481	.25	7499	.33	74260	1.49	4085	1.26	uA748CV	.44
7482	.25	7499	.33	74261	1.49	4086	1.26	uA748CV	.44
7483	.25	7499	.33	74262	1.49	4087	1.26	uA748CV	.44
7484	.25	7499	.33	74263	1.49	4088	1.26	uA748CV	.44
7485	.25	7499	.33	74264	1.49	4089	1.26	uA748CV	.44
7486	.25	7499	.33	74265	1.49	4090	1.26	uA748CV	.44
7487	.25	7499	.33	74266	1.49	4091	1.26	uA748CV	.44
7488	.25	7499	.33	74267	1.49	4092	1.26	uA748CV	.44
7489	.25	7499	.33	74268	1.49	4093	1.26	uA748CV	.44
7490	.25	7499	.33	74269	1.49	4094	1.26	uA748CV	.44
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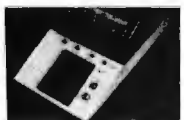
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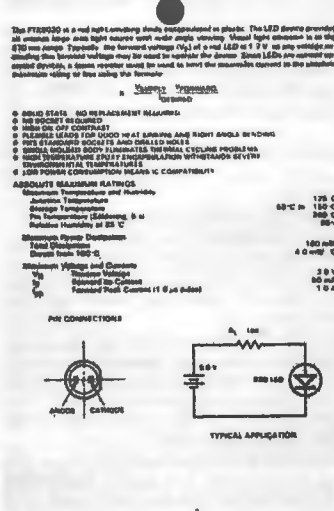
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A diagram showing a 5-pin DIN connector (labeled '5-PIN DIN') being connected to a 15-pin DIN connector (labeled '15-PIN DIN'). The 5-pin connector is shown with its pins inserted into the 15-pin connector's receptacle.

2⁹⁹

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OCTOBER 1976

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
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